Appendix E Report on Ground-Penetrating Radar Surveys Method Investigation Honolulu High-Capacity Transit Corridor Project (HHCTCP)

GPR Survey

Background

The use of Ground-Penetrating Radar (GPR) for this study was specifically dictated in the HHCTCP Programmatic Agreement. The purpose of this investigation was to evaluate the efficacy of GPR surveys within the context of urban Honolulu, to test this method's ability to map stratigraphy, as well as locate subsurface cultural deposits, including human burials. The subsurface mapping capabilities and depth information that can be acquired by GPR make it a promising geophysical technique for imaging stratigraphy and subsurface features of interest, especially human burials. As there are a number of archaeologically sensitive areas within the HHCTCP project corridor it is important to assess whether or not sensitive cultural deposits (i.e., human burials) can be located and mapped in a non-invasive way. Additionally, this study also seeks to improve the effectiveness of GPR data analysis through "ground truthing" (comparison of GPR results with actual excavation results)

Previous GPR surveys conducted in nearby locations have demonstrated the potential of GPR to map stratigraphy and subsurface features, though overall depth penetration and feature resolution remain a concern (O'Hare et al. 2009; Pammer et al. 2009). A preliminary GPR investigation for the HHCTCP project conducted by TAG Research by Sturm Inc. sought to evaluate and test which antenna frequencies, collection parameters, and processing procedures would be the most effective for potentially mapping and identifying the cultural features of interest (Sturm 2010). Sturm (2010) concluded that "GPR mapping has use and potential for imaging buried features in this urban environment" (Sturm 2010: 34). Additionally, Sturm recommends that a 400 MHz antenna be utilized to conduct the HHCTCP GPR survey, as it "provided the best overall quality data, allowing high resolution mapping of target features of interest (including burials) to a depth of approximately 1 to 1.5 meters" (Sturm 2010: 4).

This report also intends to offer a reference for future archaeological work within or near the study area that could benefit from the use of GPR analysis to investigate stratigraphy or potentially identify cultural layers or features. The work is presented in a way that allows the reader to directly compare the GPR results to "ground-truthed" excavation results. The report provides a detailed description of field methods, survey methodology, data collection parameters, post-processing, and an interpretation and summary section. The size and scope of this investigation provides a rare opportunity to interpret an intermittent GPR cross-section through one of Hawaii's more developed urban environments.

Field Methods

GPR Technology and Limitations

Ground-penetrating radar data are acquired by transmitting pulses of electromagnetic energy, in the radar frequency range, into the ground via a sending antenna. Each time a radar pulse encounters a material with a different density, electrical conductivity, or chemical composition, a

portion of the radar energy will reflect back to the surface and be recorded via a receiving antenna. The remaining radar energy will continue to pass into the ground to be further reflected, until it finally dissipates with depth. Reflection features may include discrete objects, stratigraphic layering, or other subsurface anomalies such as subsurface disturbances associated with utility installation or human interment.

The effectiveness of GPR is highly dependent on local soil conditions. The penetration depth of GPR is determined by antenna frequency and the electrical conductivity of the earthen materials being profiled (Daniels 2004). Soils having high electrical conductivity rapidly attenuate radar energy, restrict penetration depths, and severely limit the effectiveness of GPR (USDA NRCS GPR Methodology n. d.). The electrical conductivity of soils increases with increasing water, clay and soluble salt contents.

GPR suitability maps created by the National Resource Conservation Service (NRCS) were reviewed in an attempt to anticipate the predominant soil matrix within the project area and to assess the relative suitability of GPR application. Figure 41 shows the project area on the NRCS GPR Suitability Map for Hawai‘i. The project area is shown to predominantly traverse lands within the low to very low GPR suitability range. The NRCS provides the following discussion when defining their GPR suitability categories:

> Areas dominated by mineral soil materials with less than 10 percent clay or very deep organic soils with pH values < 4.5 in all layers have very high potential for GPR applications. Areas with very high potential afford the greatest possibility for deep, high resolution profiling with GPR. However, depending on the ionic concentration of the soil solution and the amounts and types of clay minerals in the soil matrix, signal attenuation and penetration depths will vary. With a 200 MHz antenna, in soils with very high potential for GPR, the effective penetration depth has averaged about 16.5 feet. However, because of variations in textural layering, mineralogy, soil water content, and the ionic concentration of the soil water, the depth of penetration can range from 3.3 to greater than 50 feet.
>
> Areas dominated by mineral soils with 18 to 35 percent clay or with 35 to 60 percent clay that are mostly low-activity clay minerals have moderate potential for GPR. Low activity clays are principally associated with older, more intensely weathered soils. In soils with moderate potential for GPR, the effective penetration depth with a 200 MHz antenna has averaged about 7 feet with a range of about 1.6 to 16 feet. Though penetration depths are restricted, soil polygons with moderate potential are suited to many GPR applications.
>
> Mineral soils with 35 to 60 percent clay, or calcareous and/or gypsiferous soils with 18 to 35 percent clay have low potential for GPR. Areas with low potential are very depth restrictive to GPR. In soils with low potential for GPR, the depth of penetration with a 200 MHz antenna has averaged about 1.6 feet with a range of about 0.8 to 6.5 feet. Areas that are unsuited to GPR consist of saline and sodic soils. These soil map units are principally restricted to arid and semiarid regions and coastal areas of the United States. (USDA NRCS GPR Methodology n. d.)

Note that the estimated depth penetration by the NRCS is based on the use of a 200MHz antenna. The current survey utilizes a 400MHz antenna, which balances radar penetration depth with image resolution, so all projected depth estimates by the NRCS must be cut in half. Thus average depth penetration would be 3.5 feet (1 m) in moderate suitability areas and 0.8 feet (0.2 m) in low suitability areas.

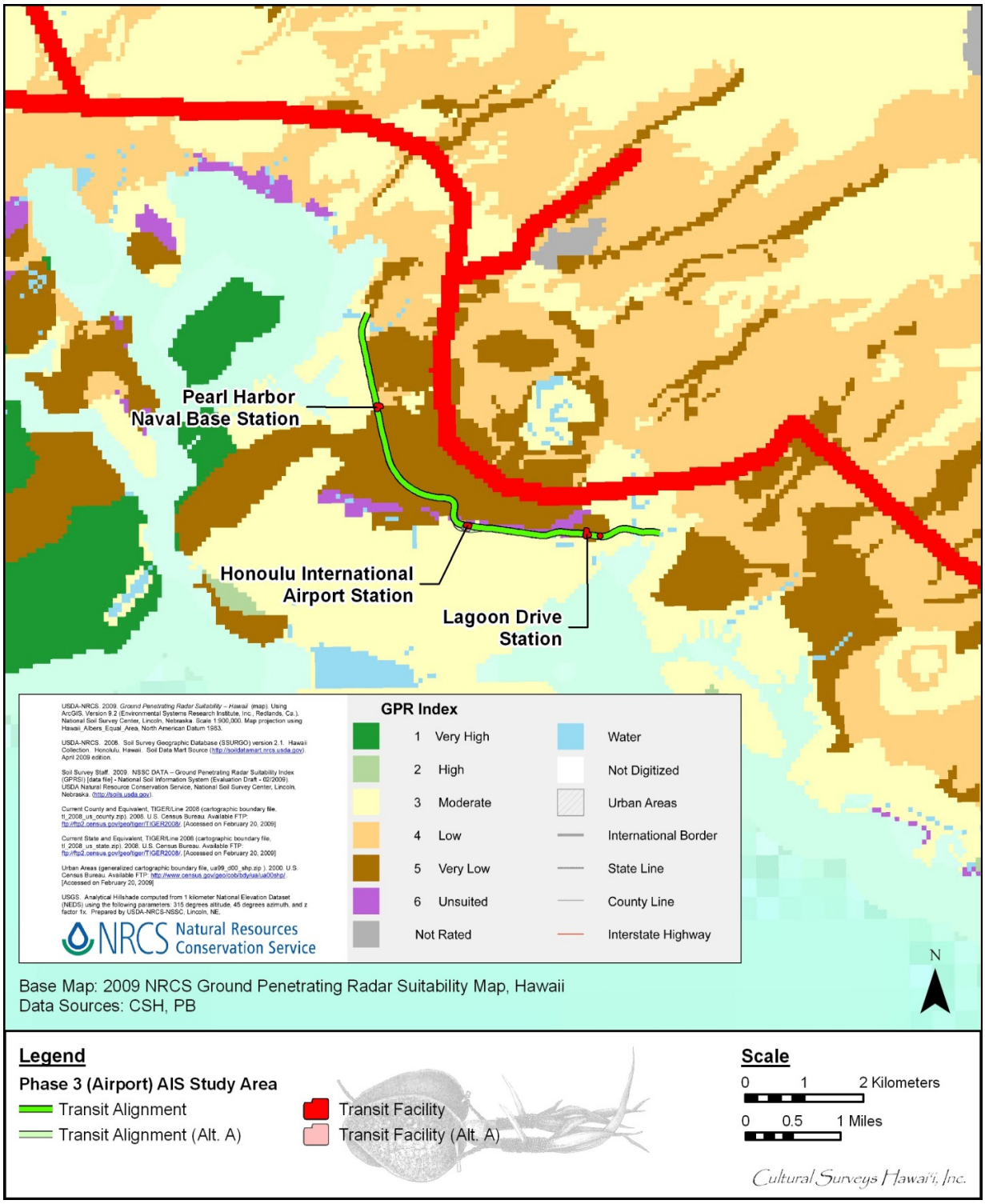

Figure 41. GPR suitability map (source: National Resource Conservation Service) showing the location of the study area

Survey Methodology

Forty-seven test excavations were surveyed and excavated during the Airport (phase 3) AIS. The excavations tested two elements of the rail construction: support columns and utility relocation corridors. The test excavation size for the support columns was generally 90 cm by 3 meters, while utility corridor test excavations measured 60 centimeters by 6 meters. GPR grids were designed to balance maximum coverage and safety. Many of the test trenches were located in busy streets and required traffic control, which limited the size of the GPR grids. Additionally, the size of the GPR grids was dictated by obstacles near the surveyed excavation margins including: trees, signs, curbs, etc. GPR grids were large enough to accommodate for slight test excavation shifts in order avoid utilities or other obstacles.

The GPR survey was conducted using a Geophysical Survey Systems, Inc. (GSSI) SIR-3000 system equipped with 400 MHz radar antenna, which was moved along transects within a survey grid (Figure 42). Transects were collected in both the Y and X directions, originating from an arbitrary southwest corner (Figure 43). Transect spacing for the Y transects were set at an interval of 25 centimeters between scans and X transects were collected every meter. Due to computer interpolation software (Radan 7; see Post-processing section below), it was only necessary to collect Y axis transects for graphic interpretation of the data for sediment analysis. However, to better identify utilities running parallel to the excavation long-axis that may fall between the Y axis scans, it was necessary to collect X axis transects. GPS points were taken at the corners of the GPR grid using a Trimble Pathfinder Pro XH (with sub-meter post-processed horizontal accuracy). Plan views were also drafted which include: GPR grid locations, surveyed test excavation locations, marked or potential utilities (designated through the “One-call” utility notification process), and any other objects that may affect analysis.

Figure 42. Photograph showing the GPR grid and antenna

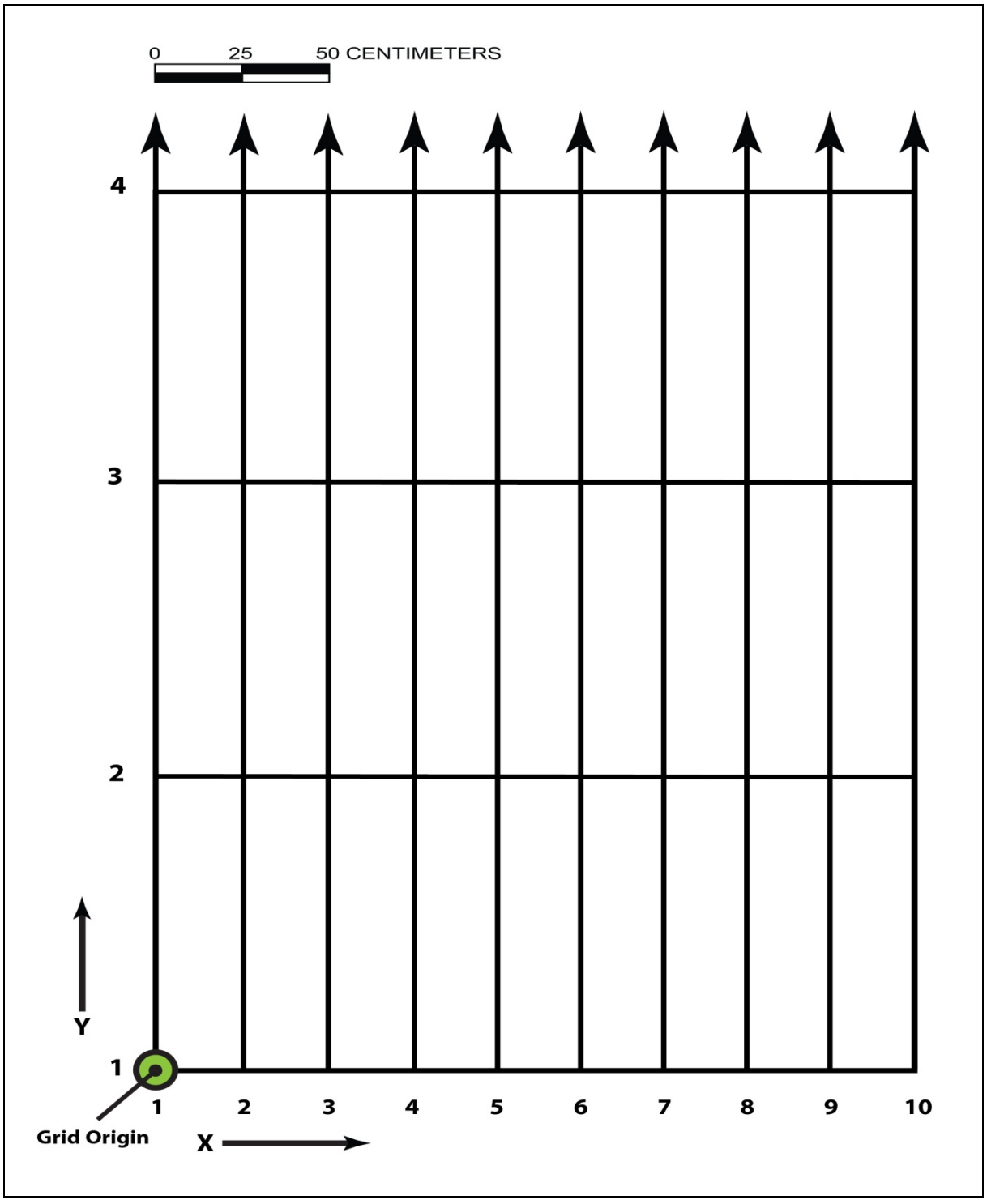

Figure 43. Transect alignment and spacing

Collection Parameters

GPR data collection parameters were held constant throughout the survey (Table 6). However, a varying dielectric constant (a mathematical constant applied to the signal return to determine depth) was used in anticipation of a complex stratigraphic sequence within the project area. USDA soil survey data indicate that the project area consists of four predominate sediment types including: Makalapa Series clay (material weathered from volcanic tuff), Keaau Series stony clay (clay loams formed in alluvium), Ewa Series silty clay loam (alluvium derived from decomposed basalt), and Fill Lands (fill sediments consisting of "material dredged from the ocean or hauled from nearby areas, garbage, and general material from other sources" are located within the project area) (Foote et al. 1972: 31). The dielectric constant was adjusted during post-processing once known depths are determined as a form of signal calibration. A dielectric range of 10.0 to 15.0 was used throughout the project area.

Table 6. GPR Data Collection Parameters

Parameter	Settings
Antenna	400 MHz
Transmission rate	120KHz
Samples	512
Format	16-bit
Range	47 nanoseconds
Dielectric	10.00 – 15.00
Rate	120
Scans per unit	75 per meter
Low Pass Filter	750MHz
High Pass Filter	200MHz

Post-processing

All collected radar data were post-processed using *RADAN 7*, which is an industry standard for GPR data processing.

RADAN 7 was utilized to generate two-dimensional depth profiles from the collected GPR data. These profiles illustrate the geometry of the reflections recorded during data collection. An analysis of these profiles can determine whether the radar energy is reflecting from a flat stratigraphic layer (seen as a distinct horizontal band on a profile), a discrete buried object (seen as a hyperbola in profile), or from stratigraphic irregularities such as subsurface disturbances associated with utility installation or human interment (also seen as hyperbolas, but usually are more ephemeral and consist of clustered reflections).

Position correction was utilized to remove unwanted surface "noise" from GPR profiles. High and low pass filters were applied to remove any excess background "noise" generated from nearby power lines, radio frequencies, etc. during data collection. Gain (signal amplification) was also applied to accent poorly defined or ephemeral reflection that are typically associated with subsurface cultural deposits.

RADAN 7 was also used to generate amplitude slice maps from the collected GPR data. Amplitude slice-maps are a three-dimensional tool for viewing differences in radar reflection amplitudes across a given surface at various depths. Amplitude slice-maps can be thought of as plan view maps or excavation level records that display GPR data at user defined depth intervals. Reflected radar amplitudes are of interest because they measure the degree of physical and chemical differences in buried materials, which in turn can indicate the presence of stratigraphic interfaces, descrete buried objects (i.e., basalt boulders, utility lines, burial caskets, etc.), or stratigraphic irregularties (i.e., subsurfaces anomalies associated with burial pits, fire pits, buried irrigation ditches, etc.). The amplitude slice maps are also important because they allow the visulization of radar reflections throughout the entire data set collected at a survey area at a given depth. This gives size and shape to collected radar reflections, which can aid in the interpretation of identified subsurface anomalies.

Amplitude slice-maps are generated through the comparison of radar reflection amplitudes recorded in vertical depth profiles, which corespond to individual transects collected within a survey grid along the X-axis (Note that while transects are collected in the Y-direction, they are actually located within the X-axis.). In this method, amplitude variations are analyzed at each location where a radar reflection was recorded. Reflection amplitude data from the X-axis is then use to interpolate reflection data on to the Y-axis.

Ground Truthing

GPR interpretations, including slice maps and profiles, were provided to field crews prior to excavation of test excavations. It was intended that the GPR analysis be used to aide excavation in anticipation of stratigraphic changes, utilities, or anomalies that may represent a buried discrete object. A GPR Interpretation form was included in the test excavation documentation packets and field crews were tasked with checking the accuracy of the pre-excavation GPR analysis. Ground truthing GPR data with test excavations consisted of:

- Were there factors that limited GPR depth penetration or caused image distortion?
- Were there GPR anomalies that corresponded to utility lines (metal or plastic), construction debris, boulders (basalt or limestone), previously backfilled excavations, concrete slabs, trash pits, coffin burials, traditional Hawaiian burials, etc.?
- How accurate were pre-excavation GPR interpretations? (Provide specific discussions in relation to both slice maps and profiles.) Were subsurface features present where indicated? Were indicated depths accurate? If initial analysis was inaccurate, try to provide an explanation for the documented anomalies.
- Were any subsurface features or sediment transitions present that were not recorded by the GPR? (i.e., utility lines, trash pits, burials, drastic stratigraphic transitions, etc...)

The completed interpretation forms were then used to compile an excavation by excavation analysis detailing the GPR results, usefulness, and accuracy of the GPR data (Figure 47 through Figure 140). For the purpose of this report the excavation by excavation interpretations include: geospatial referencing of the excavation, proximity to utilities, a brief review of both slice and profile maps, and a visual comparison of excavated profiles and GPR signal profiles. GPR results for all forty-seven test excavations for HHCTCP Phase 3 are presented following the Summary.

Interpretation and Results

Slice Map Analysis

GPR slice maps are a three-dimensional tool for imaging radar reflection amplitudes across an axial plane at various depth intervals. Slice maps can essentially be thought of as a GPR plan-view of the survey area. By combining and interpolating transect profiles in a plan view, slice maps give shape to anomalous signal returns that extend into multiple profiles. This was particularly useful when looking for subsurface man-made structures. During this project slice maps were primarily used to locate linear features (utilities) and larger discrete objects. Slice maps were also effective in displaying horizontal stratigraphic irregularities and vertical terminations. For this project, slice maps were generated in *Radan* 7 using Color Table 1 which is able to display very subtle changes in reflectivity as well as highly contrasting reflection transitions. Figure 44 is an annotated example of a GPR slice map used for this project and a guide for interpretation.

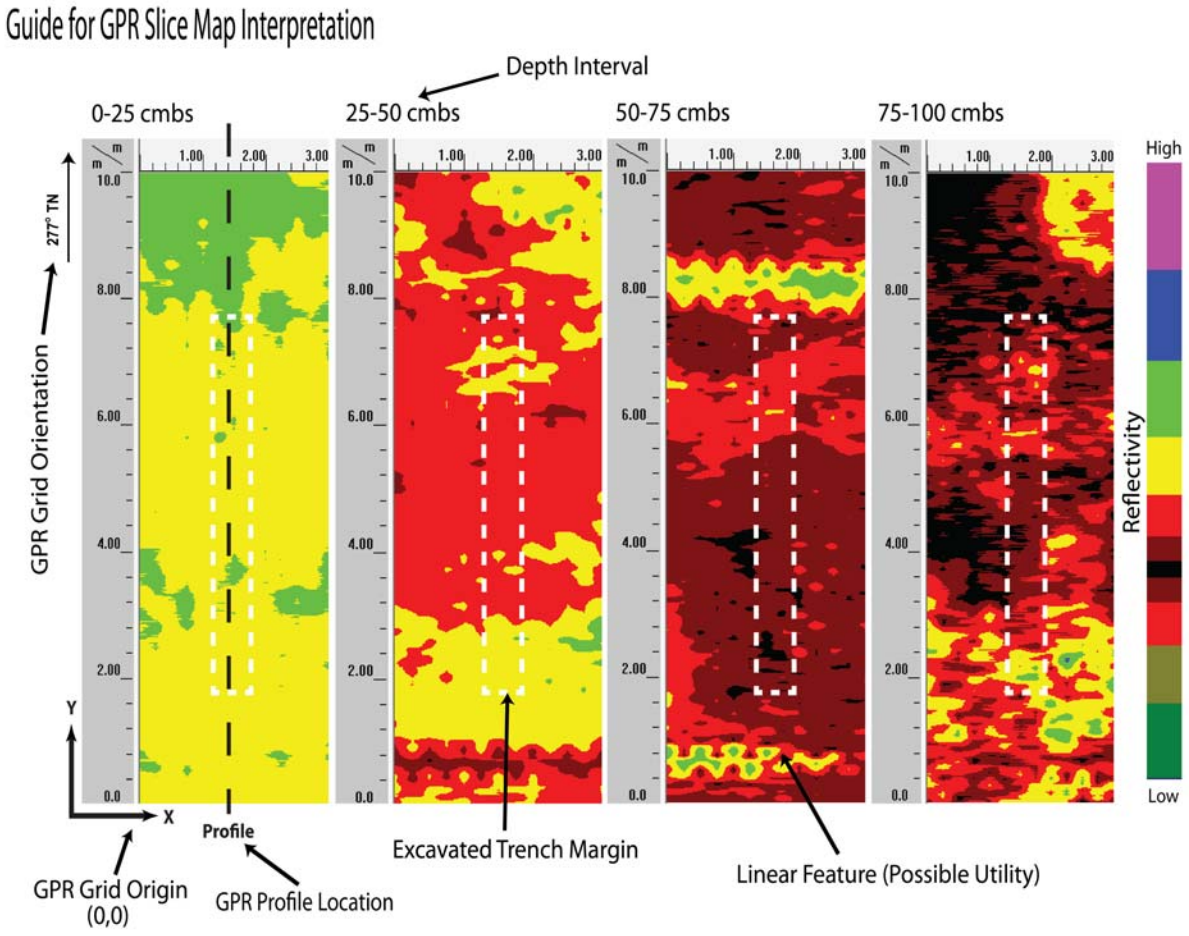

Figure 44. Guide for GPR Slice Map Interpretation

Profile Analysis

Following post-processing, interpretation of GPR profiles began with locating and identifying reflection interfaces. It was important to determine if changes in reflectivity represent actual subsurface transitions/features or signal interferences. Interferences in signal return can result from random electromagnetic noise (i.e., cellular devices, ELF emissions from power lines), harmonic signal resonance, standing surface water, etc. Signal interference can take the visual form of regularly repeating reflections or random noise that will display a "digitized" or discontinuous look on the GPR profiles. Transmitted signals can also harmonically resonate, which will cause repeating signal horizons and false increases in reflectivity. Harmonic resonance is often caused by the transmitted signal encountering a metal object creating a "ringing" effect. Rough surface topography can also cause the GPR antennae to lose contact or "uncouple" the transmitted signal from the surface effectively scattering the signal. Examples of signal interference can be seen at the bottom of Figure 45. Signal filters can be applied to remove interference during post-processing but should be kept to a minimum to avoid losing subtle signal changes that can offer information. Once the determination of clean signal versus interference had been made, GPR profile analysis for this project was approached in three ways: locating signals representing discrete subsurface objects, identifying sediment material based on reflectivity and signal texture, and determining stratigraphy based on reflectivity transitions.

Discrete Objects

The signal profile generated by a discrete buried object is generally hyperbolic in form. The apex, or top of a hyperbola, represents the origin of the object. In general, larger objects form larger hyperbolas and the width of the hyperbolic apex is relative to the diameter or width of the object. This method of analysis is used to locate utilities, cultural deposits, building structures, etc. It is important to consider the data collection transect orientation and spacing carefully when applying this method. Objects that are located between collection interval lines may be missed or misread. Features that are aligned parallel to the collected signal transect will form continuous horizontal reflections. For instance, a pipe that runs parallel to the collected transect will appear as a horizontal line on the GPR profile. That is why it was important to collect data in both x and y directions in the event that a liner object, such as a pipe, was located between the transect intervals. A good example of a hyperbolic reflection created by a discrete object (utility pipe) is located on Figure 45.

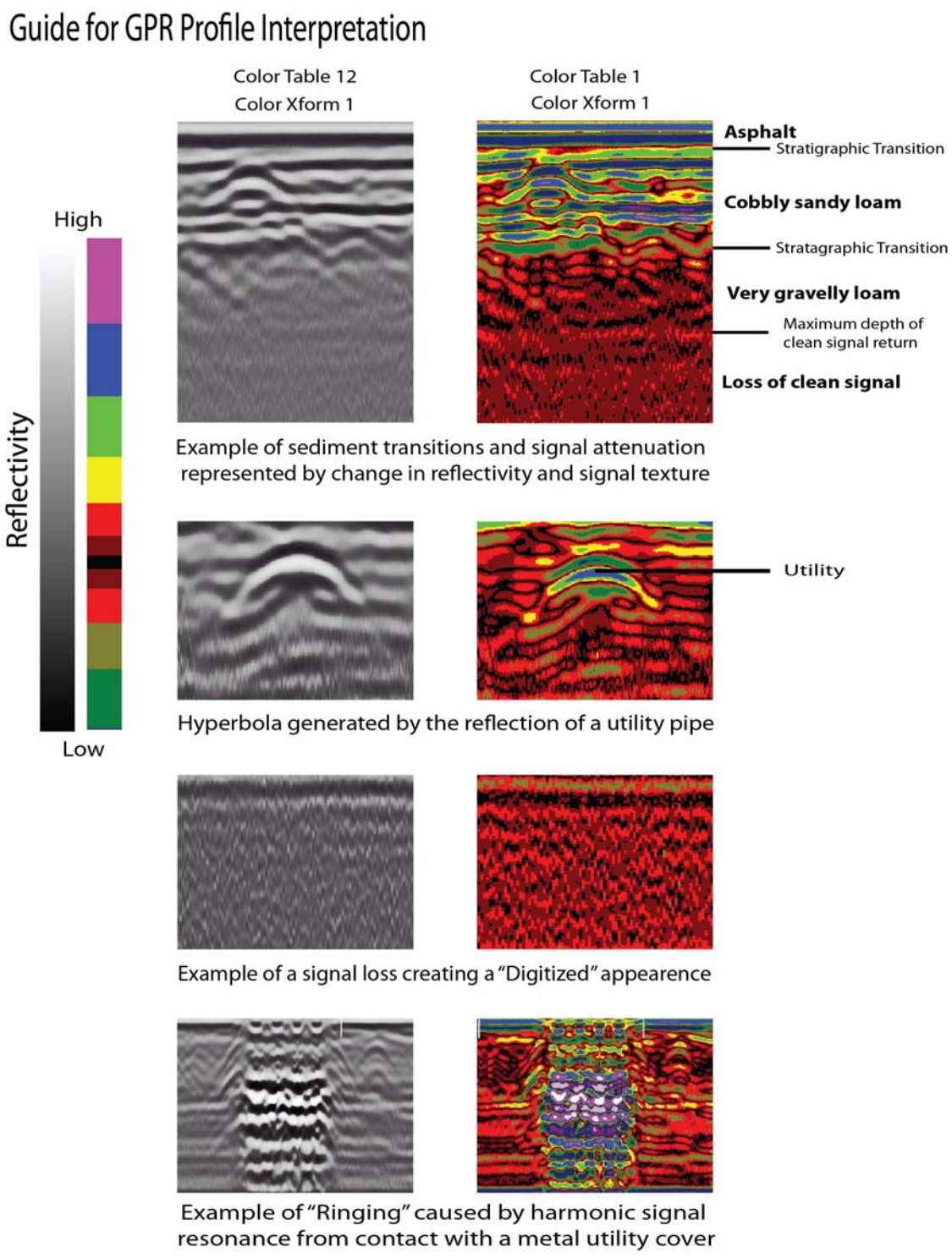

Figure 45. Guide for GPR Profile Interpretation

During Phase 3 of the HHCTCP, discrete objects observed in the GPR data and subsequent excavations were limited to utilities and tree roots. No culturally significant discrete objects were observed in the test excavations. GPR Slice maps and profiles were combined in a statistical study to determine the accuracy of locating discrete objects. With the exception of Excavation 13, which contained a sizable root that was observed in the GPR profile, the only discrete objects that displayed clear discernible reflections were utilities. The study found that out of the combined 94 profiles and slice maps, 28 contained utilities that were ground truthed by excavation. 39 percent of these excavations showed a clear signal in the GPR data that corresponded to the utility. 61 percent of the utilities encountered during these excavations did not display a clear signal response in the GPR analysis. Factors that contributed to the low level of detection include: depth of utility located beyond the GPR "visibility" range, no clear sediment transition associated with the utility, and difficulty to discern very shallow utilities in highly compacted sediments. Further testing in Phase 4 of the project is needed to assess the overall accuracy of GPR to locate discrete subsurface objects.

Sediments

GPR data can be used as a non-invasive method to determine subsurface sedimentation based on signal reflectivity and texture. Signal reflectivity is affected by variations in material density, compaction, geochemistry of sediment material, water content, etc. These factors ultimately determine material conductivity and signal attenuation. Less conductive materials like sand or gravel have a greater degree of reflectivity. Conductive materials like silt or clays attenuate the transmitted signal and are less reflective. Signal texture is a way to describe signal patterns created by changes in signal shape and reflectivity. Figure 46 is a compilation of signal texture profiles that correspond to sediments found in the project area. Sandy sediments displayed higher reflectivity and wavy signal topography. Within the project area, sediments rich in clay or silt generally displayed lower reflectivity with smooth signal topography. Sediments with high percentages of gravel to cobble inclusions were indicated by multiple small hyperbolas, which are best observed in Color Table 12 profiles.

A goal of this study was to analyze methods of using GPR analysis as a non-invasive way to locate naturally deposited sediments in the project area and use this information to determine probability of encountering pre-Contact culture at the site. Unfortunately Phase 3 of the HHCTCP was dominated by historic fill events which capped, truncated, or replaced naturally deposited sediments. No in-situ undisturbed sand deposits or cultural layers were encountered during this phase of the project. Most naturally deposited sediment types observed during Phase 3 were located below the maximum depth of clean GPR signal return. The maximum depth of clean signal return for the Phase 3 project area averaged between 75 and 100 cmbs. This signal "visibility" corroborates with the USDA GPR suitability rating of low to moderate for this area. The water table was also located beyond this range in every excavation. The only naturally deposited sediments that were encountered during excavation and within the zone of clean signal return included: shallow coral shelf, basaltic ash, and decomposed basaltic bedrock. Detecting the coral shelf was difficult due to highly variable nature of coral polyp growth and density. Generally speaking though, coral shelf displayed low reflectivity and wavy signal topography. Basaltic ash and decomposed basaltic bedrock displayed higher reflectivity with smooth signal topography.

Recognition of patterns in signal texture and reflectivity requires a great deal of experience and can be somewhat subjective in nature. While clear patterns are emerging in the data, it is difficult to quantitatively assess accuracy of this method. Using GPR analysis for determination of sediment material should be viewed as an approximation.

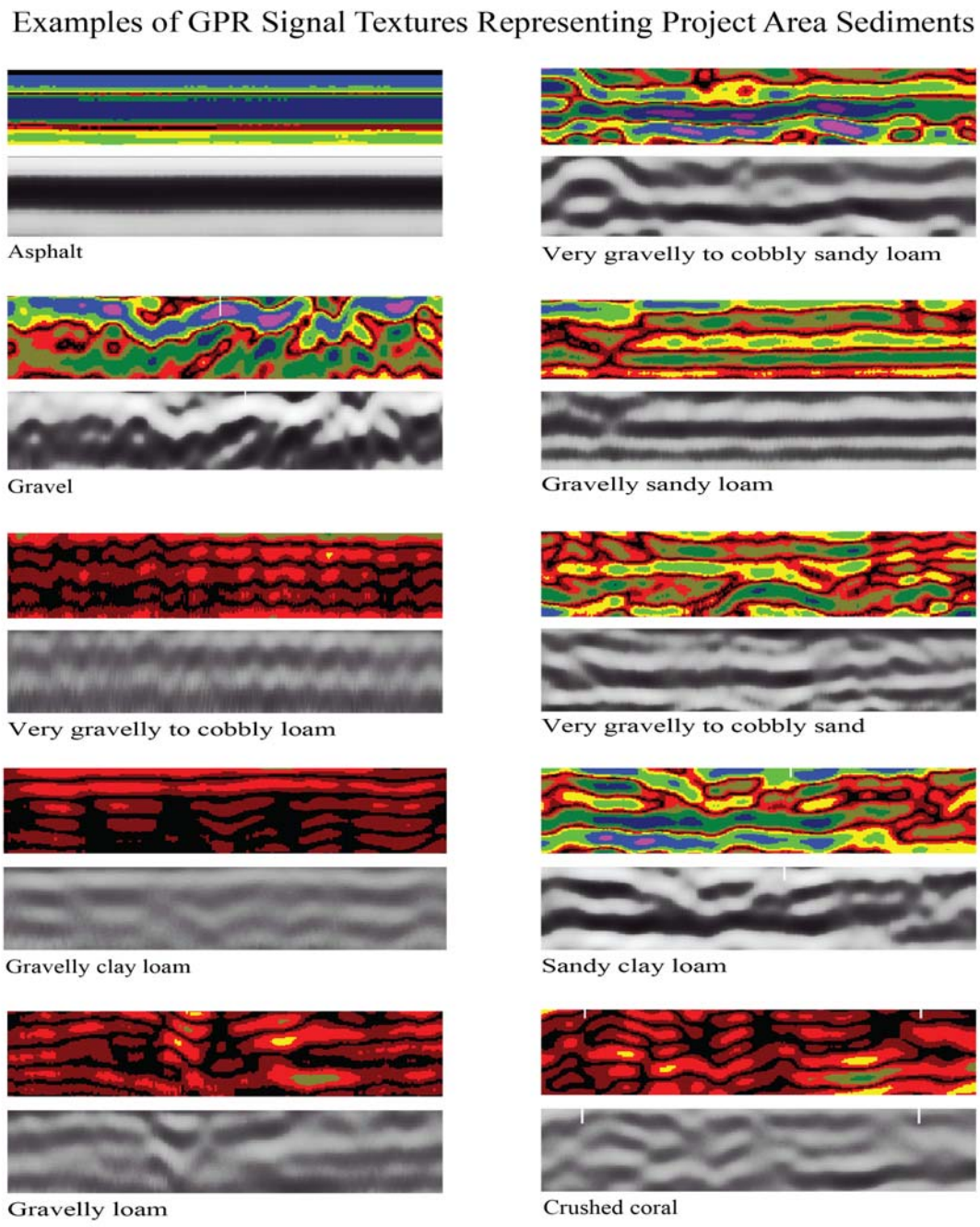

Figure 46. Examples of GPR Signal Textures Representing Project Area Sediments

Stratigraphy

In recent years, GPR analysis has become a proven method for determining subsurface stratigraphic sequences by analyzing changes in signal reflectivity. Stratigraphic transitions can be represented by abrupt changes in reflectivity. These changes are often in the form of horizontal banding sequences as observed in the GPR profiles. As previously stated, signal transitions can be caused by variations in material density, compaction, geochemistry of sediment material, water content, etc. Figure 45 shows two distinct stratigraphic transitions based on reflectivity and horizontal banding. The first transition occurs directly below the top layer of the highly reflective asphalt. A second transition is observed bounding the higher reflectivity "cobbly sandy loam" and lower reflectivity "very gravelly loam". GPR data is also useful for locating vertical or cross-cutting stratigraphic transitions, such as utility trenches or vertical sediment truncations.

Using GPR data as a non-invasive means of stratigraphic sequencing can aide in determining the relative chronology of sediment deposition within a project area. This method of analysis can be coupled with GPR sediment analysis to determine the probability of encountering natural sedimentation in a project area. In urban areas, several stratigraphic layers might imply multiple depositional fill events associated with historic land use. A project area multiple fill events may lower the probability of encountering well preserved in-situ natural deposits.

Excavated profile and GPR Profile Visual Comparison

As a way of testing the ability of GPR to discern subsurface stratigraphy in the project area, a visual comparison between the GPR profile and the stratigraphic profile for each test excavation was conducted. Excavation profiles were aligned by orientation and adjusted to the same vertical and horizontal scale as the GPR profiles for each excavation. In some cases it was necessary to mirror the drafted profile to match the orientation of the GPR Profile. It was not possible to match collected GPR transects to the exact excavated profile location because of the variant nature of choosing which sidewall to draft following excavation and GPR transect interval spacing. As a result, GPR profiles were chosen based on proximity to the center of the test excavation, in essence creating an averaging effect for interpretation. The GPR profiles were generated in *Radan 7* using Color Tables 1 and 12 (Figure 45). Color Table 1 is very effective in displaying subtle changes in signal reflectivity which helps to distinguish sediment transitions. Color Table 12 is a universally recognized color scheme and better at distinguishing hyperbolic reflections associated with discrete objects.

Visually comparing the Phase 3 GPR profiles with the excavated profiles reveals an overall strong correlation between changes in GPR signal reflectivity and "ground truthed" stratigraphy for the project area. Comparisons only considered stratigraphic transitions within the range of clean signal return (70 – 100 cmbs). Stratums with a thickness of less than 10 cm were not considered due to the difficulty of visually resolving them on the GPR profiles. The results of the visual comparison were divided into three levels of correlation for each excavation: strong, moderate, and weak. A strong visual correlation suggests that all stratigraphic transitions confirmed by excavation were observed on the GPR profile. Stratigraphic transitions were required to be within 15 cmbs of the ground truthed origin. 70 percent (33/47) of the excavations for Phase 3 show a strong correlation with the GPR results. Moderate correlations suggest that most stratigraphic transitions are observed in the GPR profile. Stratigraphic transitions were

required to be within 25 cmbs of the ground truthed origin. 17 percent (8/47) of the excavations for Phase 3 show a moderate correlation with GPR results. A weak visual correlation suggests that very few to no stratigraphic transitions confirmed by excavation were observed on the GPR profile. Stratigraphic transitions were required to be within 50 cmbs of the ground truthed origin. 13 percent (6/47) of the excavations for Phase 3 show a weak correlation with GPR results.

Summary

Location of discrete objects has traditionally been the role of GPR analysis within the context of modern archaeology. While GPR technology can be effective in accomplishing this task, the results of this study suggest that further development is needed to increase the reliability of GPR as a tool for discrete object detection in urban fill environments. It should be noted that discrete objects encountered in Phase 3 were predominantly utilities. However, this study demonstrates that GPR can be a useful tool to map subsurface stratigraphy and sediment material types. Utilizing GPR analysis to determine the probability of encountering naturally deposited sediments within a project area could greatly enhance the general understanding of that area.

In summary, the GPR did prove to be a useful integration into the fieldwork and study of this project. Pre-excavation analysis allowed field crews to avoid utilities and anticipate stratigraphic changes that were encountered during excavation. GPR analysis and test trench excavation revealed that project area was highly disturbed, predominately consisting of historic fill events associated with urban development and grading. The few natural sediments encountered during excavation included: decomposed basalt, volcanic tuff, and coral shelf. No natural sand deposits, human burials, significant discrete objects, or culturally rich stratigraphic layers were encountered during this phase or the project. As a result, GPR data correlation was not possible to determine signal signature or characteristics of these particular features. Further testing for Phase 4 of the project will hopefully provide greater resolution to the usefulness of GPR to map stratigraphy, determine sedimentation, and locate subsurface cultural deposits, including human burials.

Excavation 01

Excavation 01 measured 0.6 meters by 6 meters and was oriented North to South and was located within a median in the center of Kamehameha Highway at the intersection of Kalaloa Street and Arizona Memorial Place on the North bank of Halawa stream.The USS Arizona Memorial Visitor Center was approximately 150 meters Northwest of the excavation. The GPR grid measured 2.5 meters by 7 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include a sewer line 6.29 meters to the Northeast. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 47).

GPR depth profiles for Excavation 01 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 48). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 15 cmbs and again around 50 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

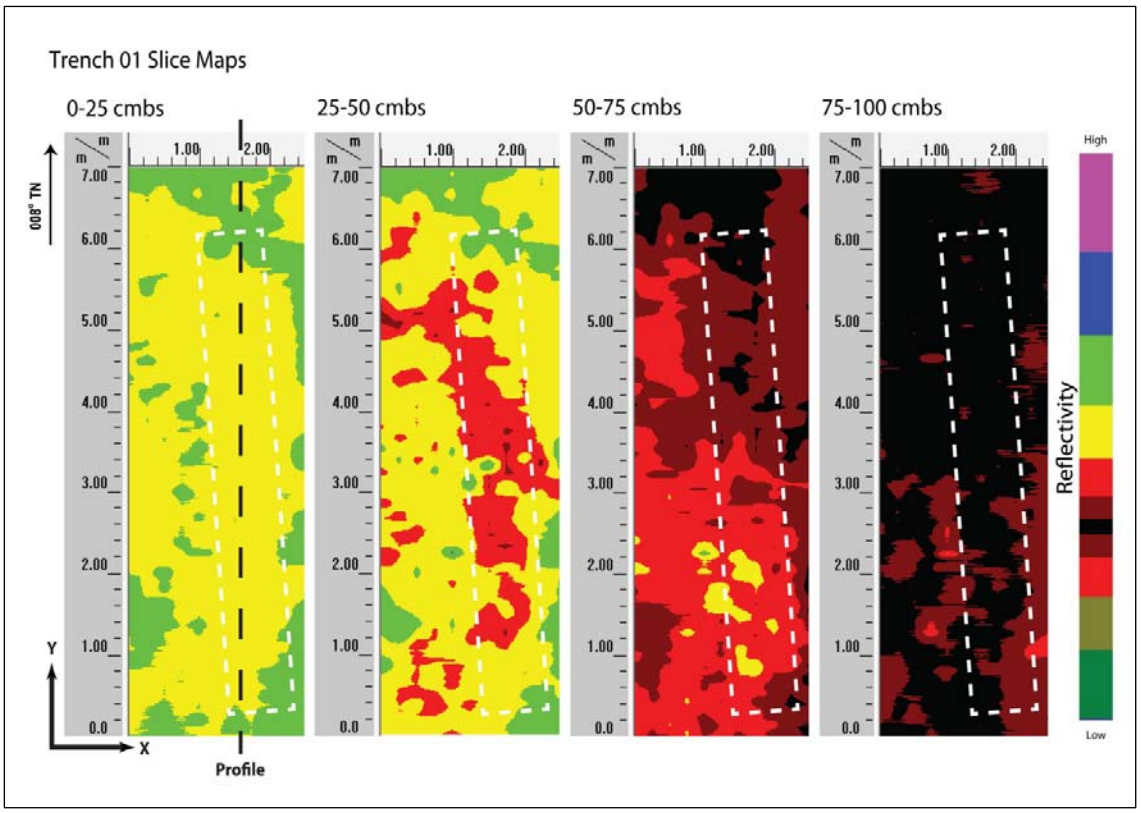

Figure 47. Slice maps of Excavation 01 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 48). The transitions from stratum Ia to Ib and Ib to Ic is clearly observed, while the transition to stratum Id is deeper than the GPR data suggested. This may be attributed to a slightly incorrect dielectric value for the area. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

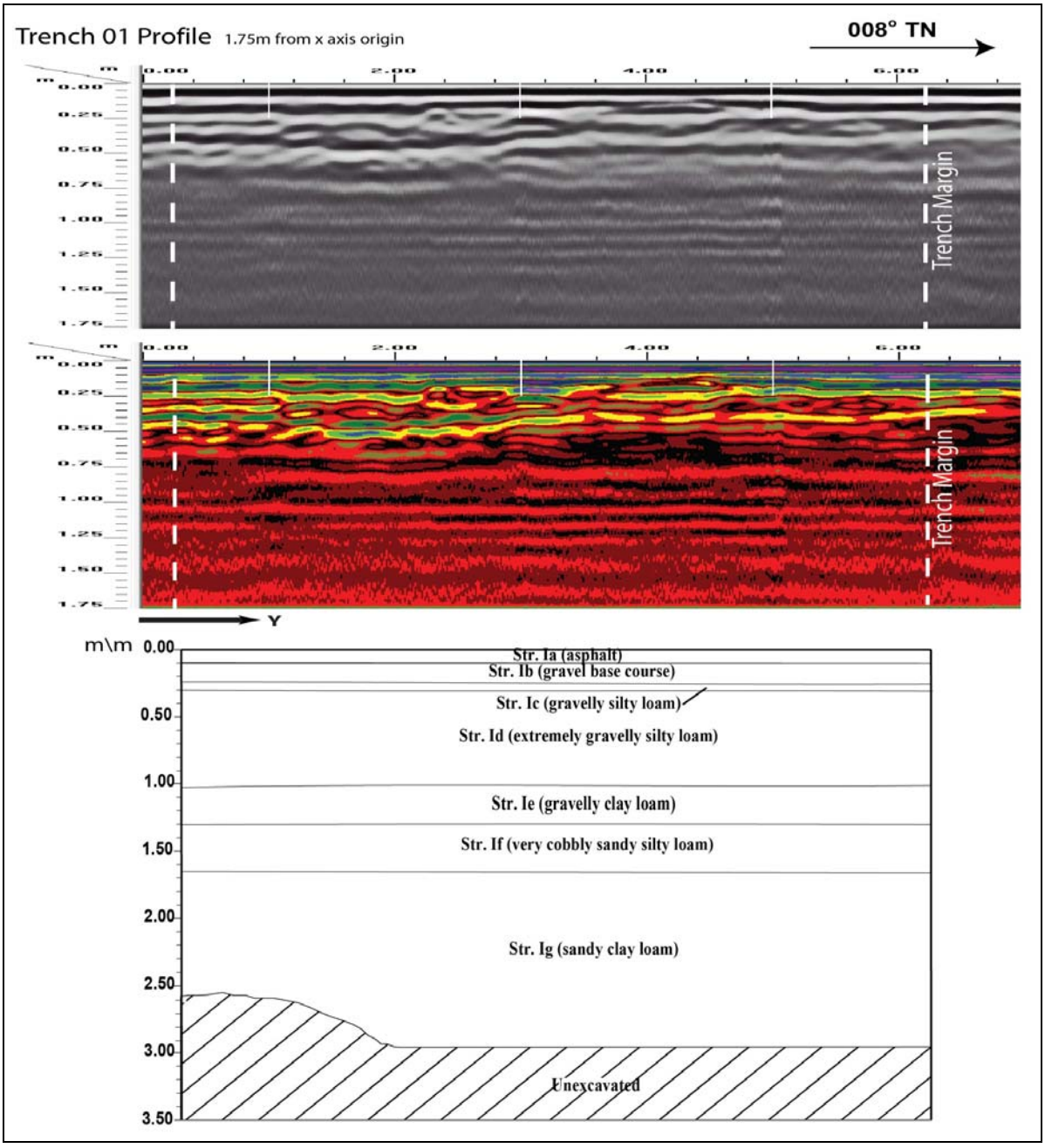

Figure 48. Visual comparison of excavated profile and GPR signal profile of Excavation 01

Excavation 02

Excavation 02 measured 0.9 meters by 3 meters and was oriented North to South and was located within a landscaped median in center of Kamehameha Highway near the intersection of Kalaloa Street on the North bank of Halawa stream. Vegetation was cleared around the perimeter of the excavation location exposing landscape fill. The GPR grid measured 2 meters by 4 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines five meters West and 10 meters East, and a gas line 1 meter to the South. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 49).

GPR depth profiles for Excavation 02 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 48). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs and again around 75 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 115 cmbs.

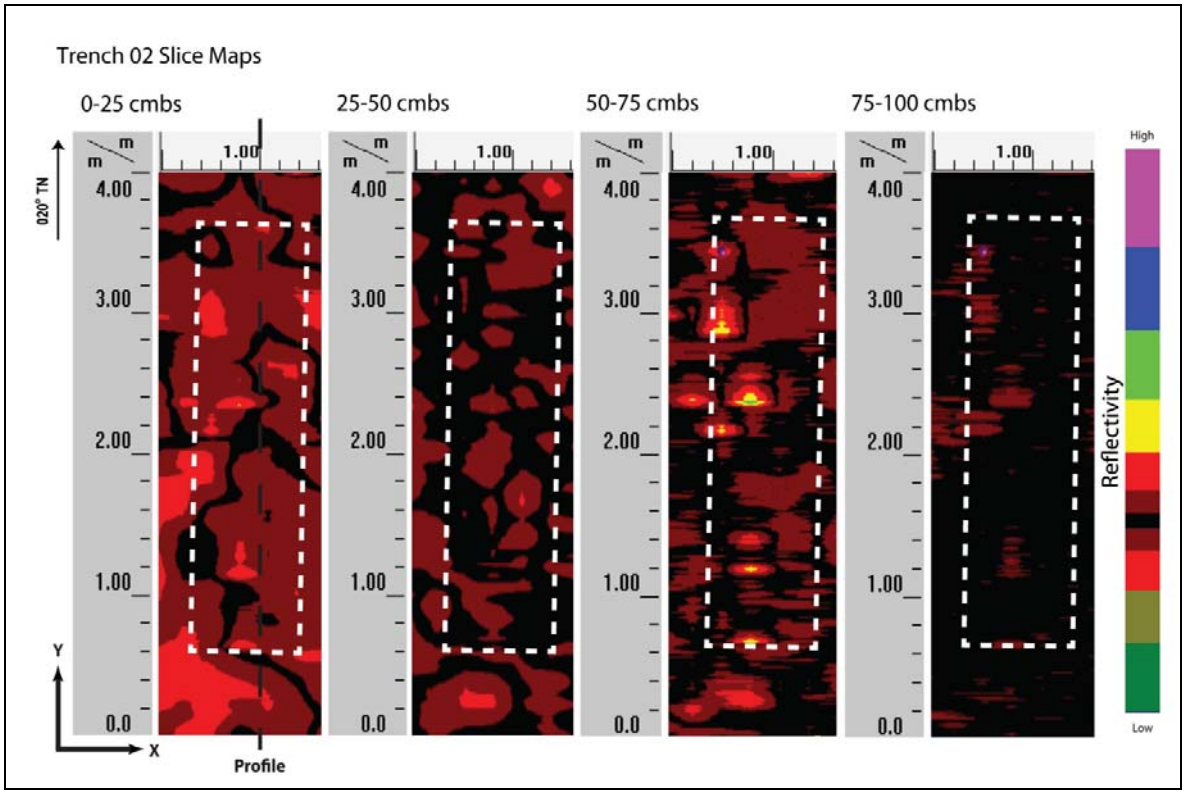

Figure 49. Slice maps of Excavation 02 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 50). The transition from stratum Ia to Ib is clearly observed while the transition to stratum Ic is not. This may be attributed to the similarity of sediment material between the two strata. The transition to stratum II is relatively clear with an increase in reflectivity around 75 cmbs. No discrete objects were observed in the GPR results or subsequent excavation.

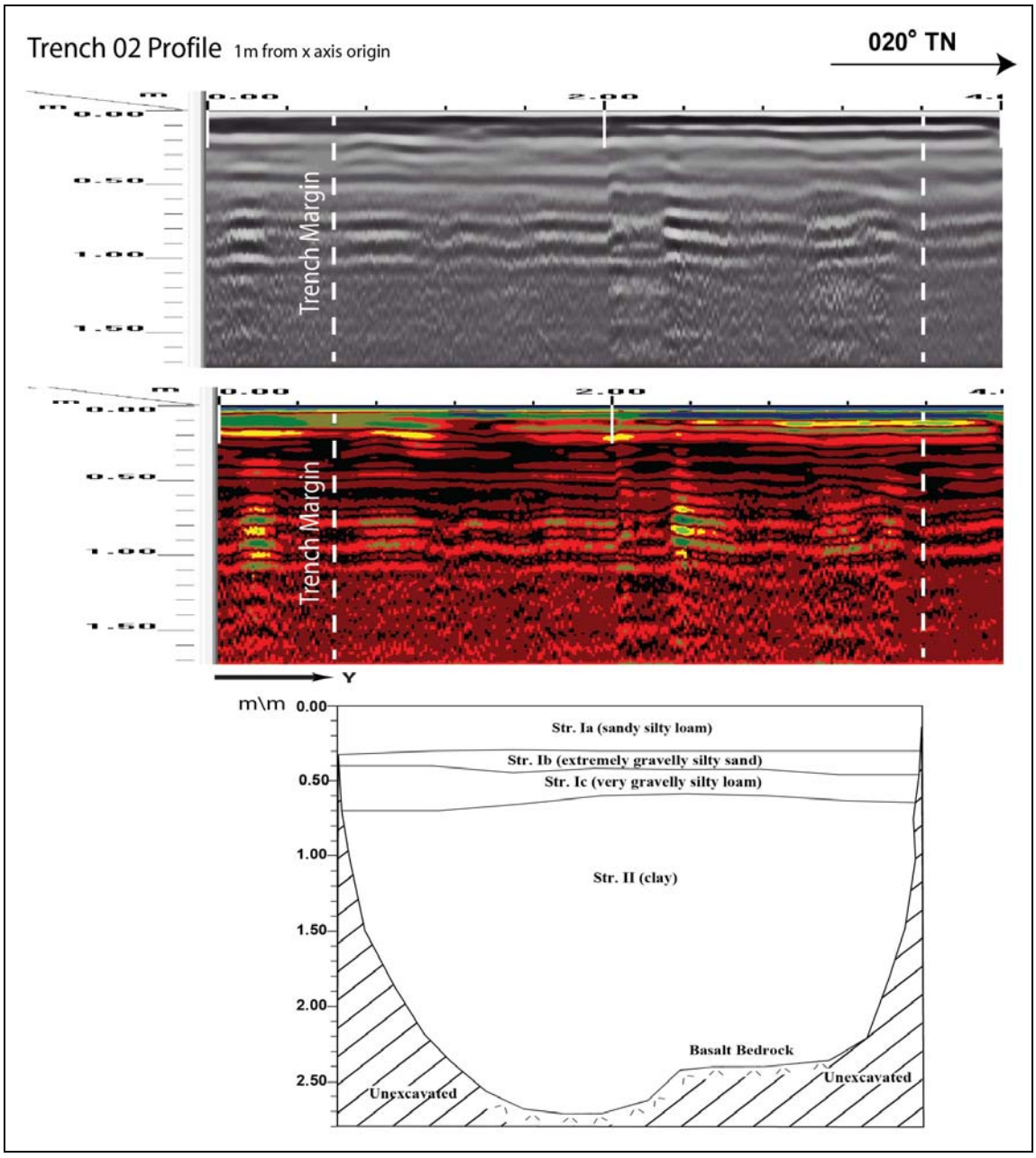

Figure 50. Visual comparison of excavated profile and GPR signal profile of Excavation 02

Excavation 03

Excavation 03 measured 0.9 meters by 3 meters and was oriented Northwest to Southeast and was located within a landscaped causeway near the sidewalk on the East side of Kamehameha Highway near the intersection of Halawa Drive on the South bank of Halawa stream. The Makalapa Naval Station was located approximately 100 meters to the Southeast of the excavation. The GPR grid measured 4 meters by 4 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: gas line 3 meters to the West, electric line 2 meters to the South. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 51).

GPR depth profiles for Trench 03 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 52). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 20 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 75 cmbs.

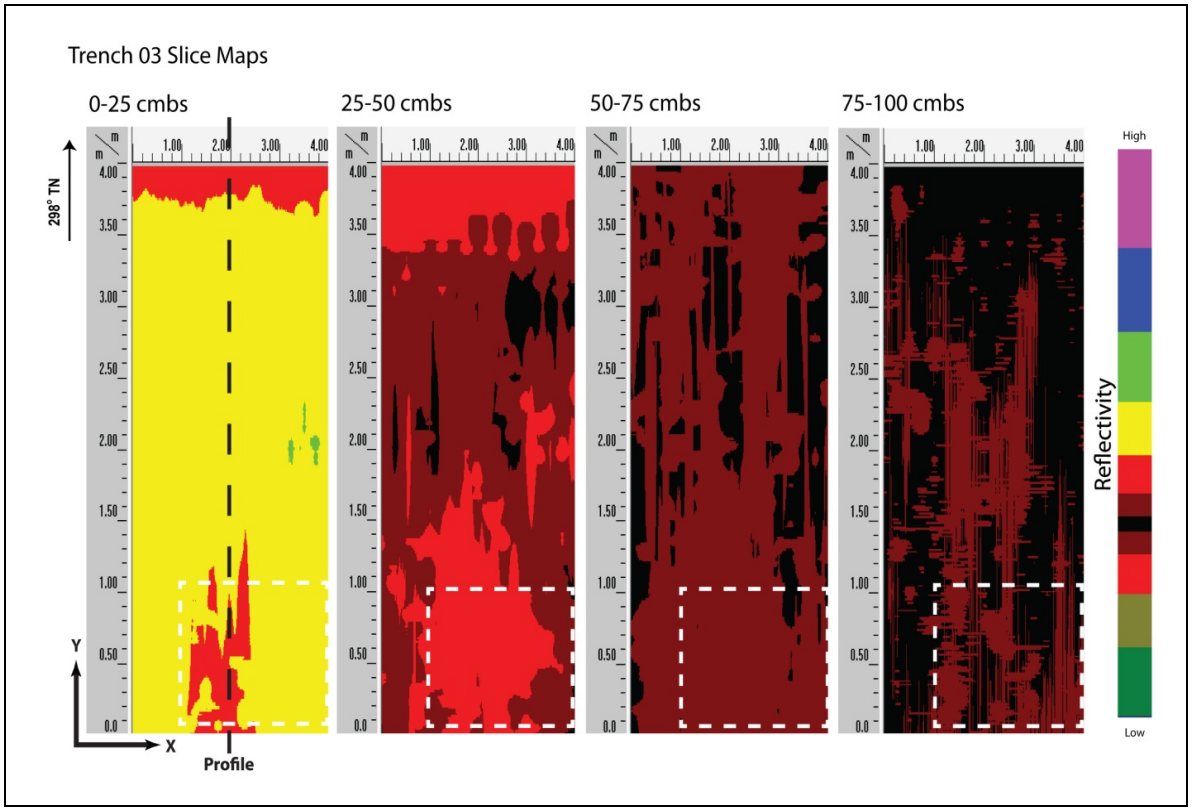

Figure 51. Slice maps of Excavation 03 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 52). The transition from stratum Ia to Ib is clearly observed while the transition to stratum Ic is not. The presence of the basalt boulders is indicated by a higher reflectivity at ~100 cmbs which does correspond well with the excavated results. No discrete objects were observed in the GPR results or subsequent excavation.

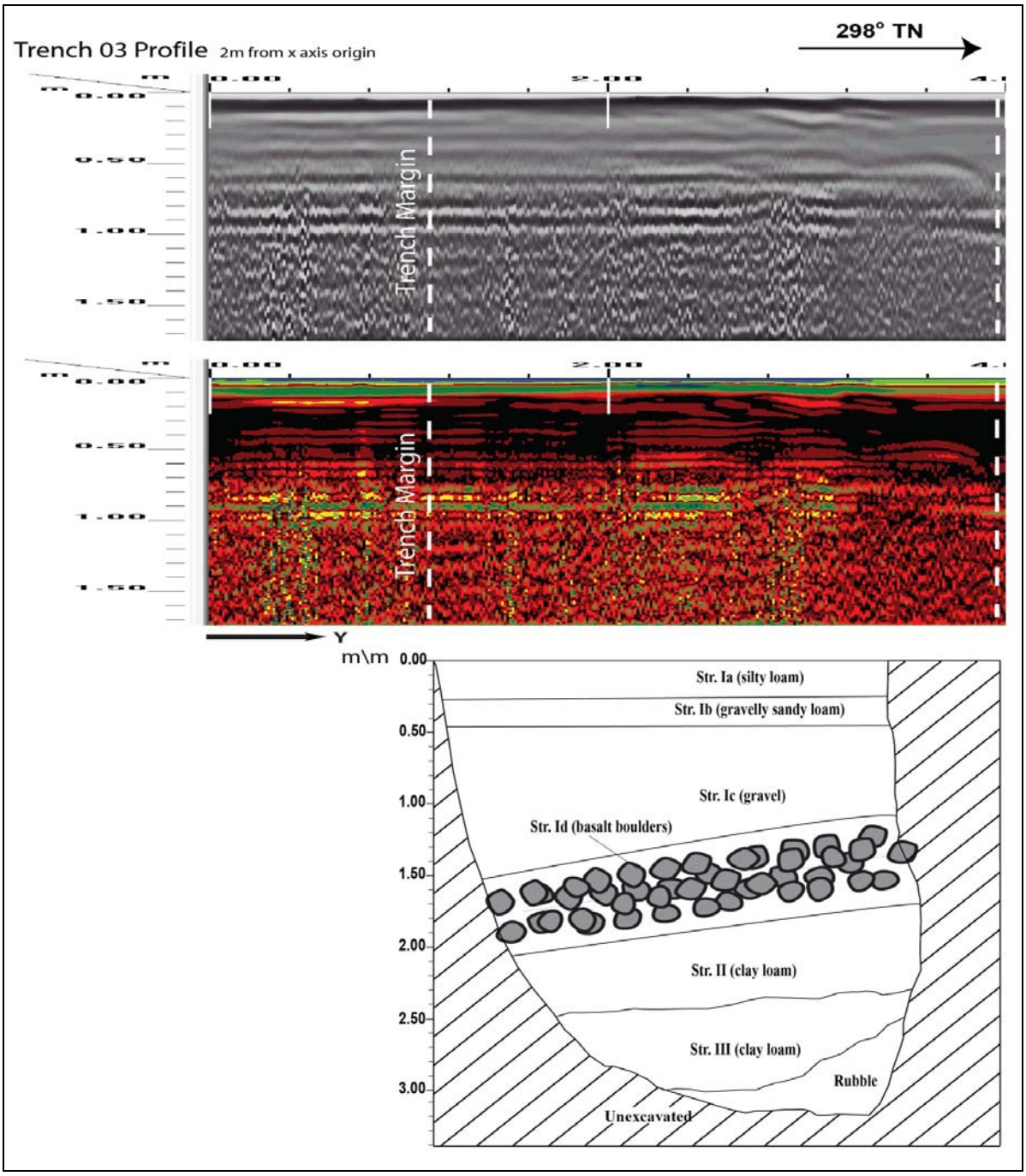

Figure 52. Visual comparison of excavated profile and GPR signal profile of Excavation 03

Excavation 04

Excavation 04 measured 0.9 meters by 3 meters and was oriented North to South and was located within a causeway along the East side of the median in the center of Kamehameha Highway near the intersection of Halawa Drive on the South bank of Halawa stream. The Makalapa Naval Station was located approximately 110 meters to the East of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include an electrical line 2 meters to the West. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 75 cmbs (Figure 53).

GPR depth profiles for Excavation 04 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 54). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 40 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 75 cmbs.

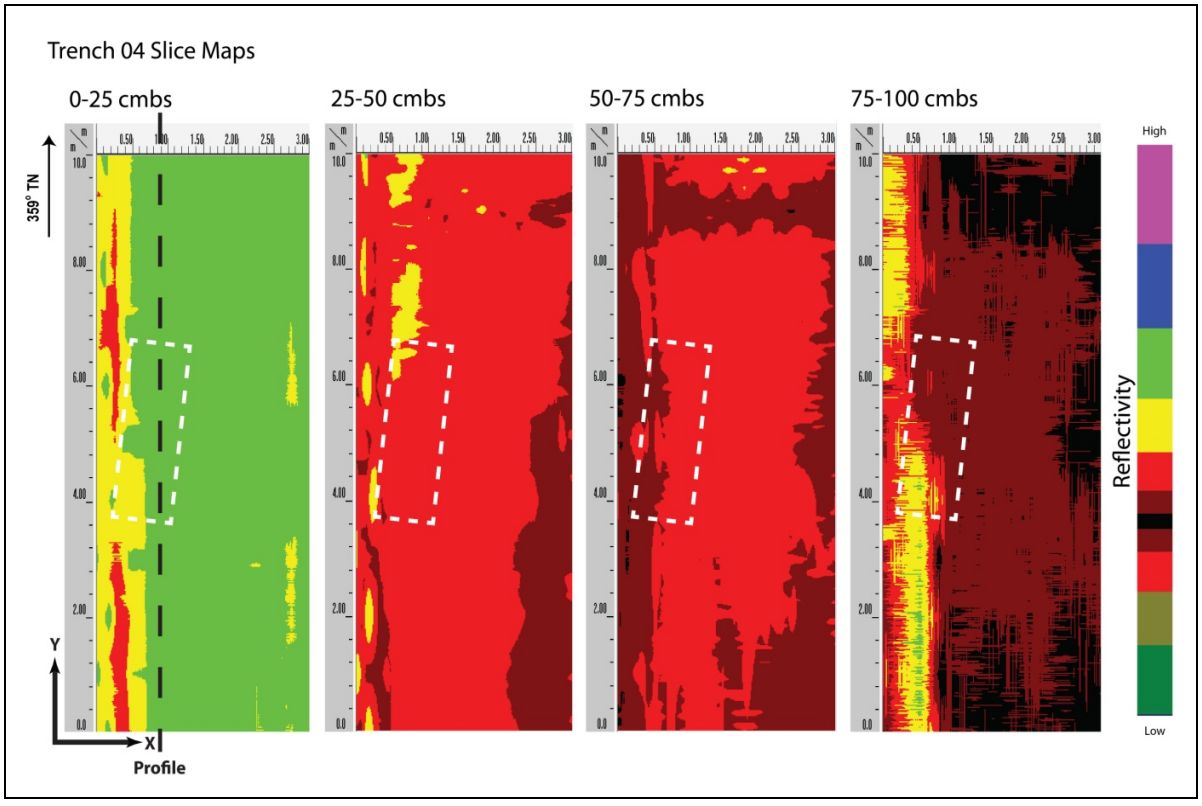

Figure 53. Slice maps of Excavation 04 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 54). The transition from stratum Ia to Ib is clearly observed. The transition to stratum Ic is also clearly indicated by a change in reflectivity and texture in the form of many small hyperbolas resultant from the reflections of the cobbles found in the soil. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

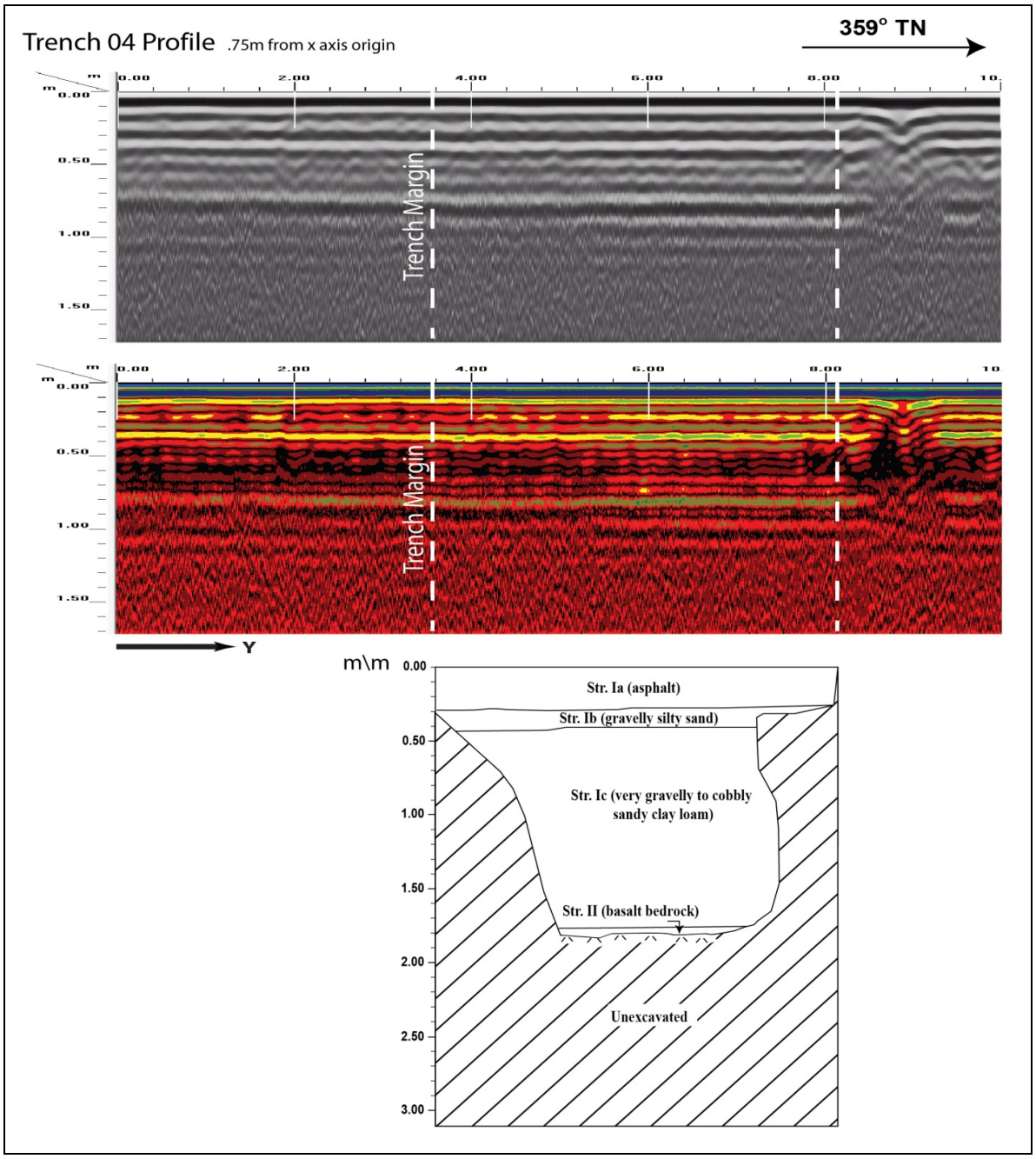

Figure 54. Visual comparison of excavated profile and GPR signal profile of Excavation 04

Excavation 05

Excavation 05 measured 0.9 meters by 3 meters and was oriented North to South and was located within the road cut of Kamehameha Highway along the West side of the median and within the far left lane 338 meters North of the Radford Drive intersection. The GPR grid measured 2.5 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water line 3 meters to the West and a cable line .5 meters to the West. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 75 cmbs (Figure 55).

GPR depth profiles for Excavation 05 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 56). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 50 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 90 cmbs.

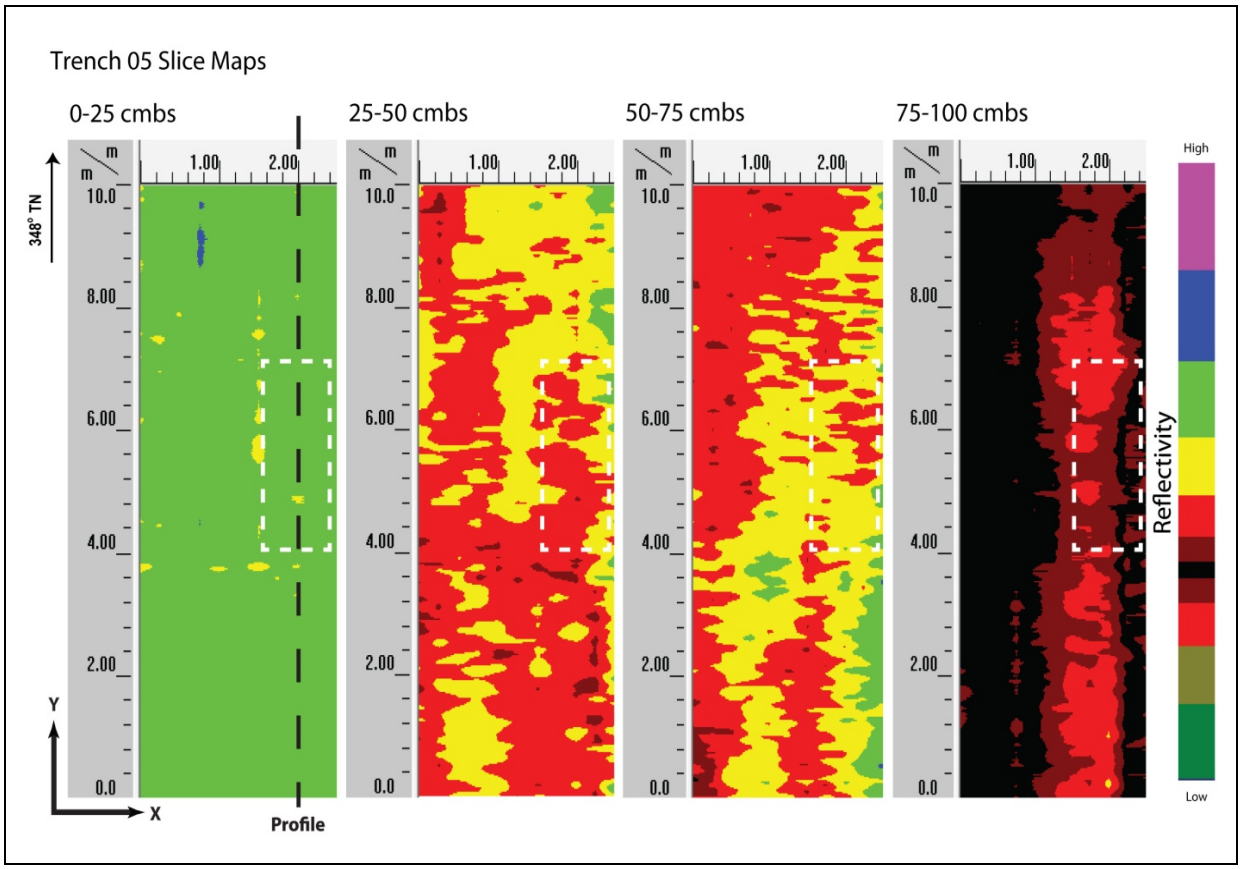

Figure 55. Slice maps of Excavation 05 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a very strong correlation in stratigraphic transitions (Figure 56). Strata Ia to II are all clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in the very gravelly strata. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

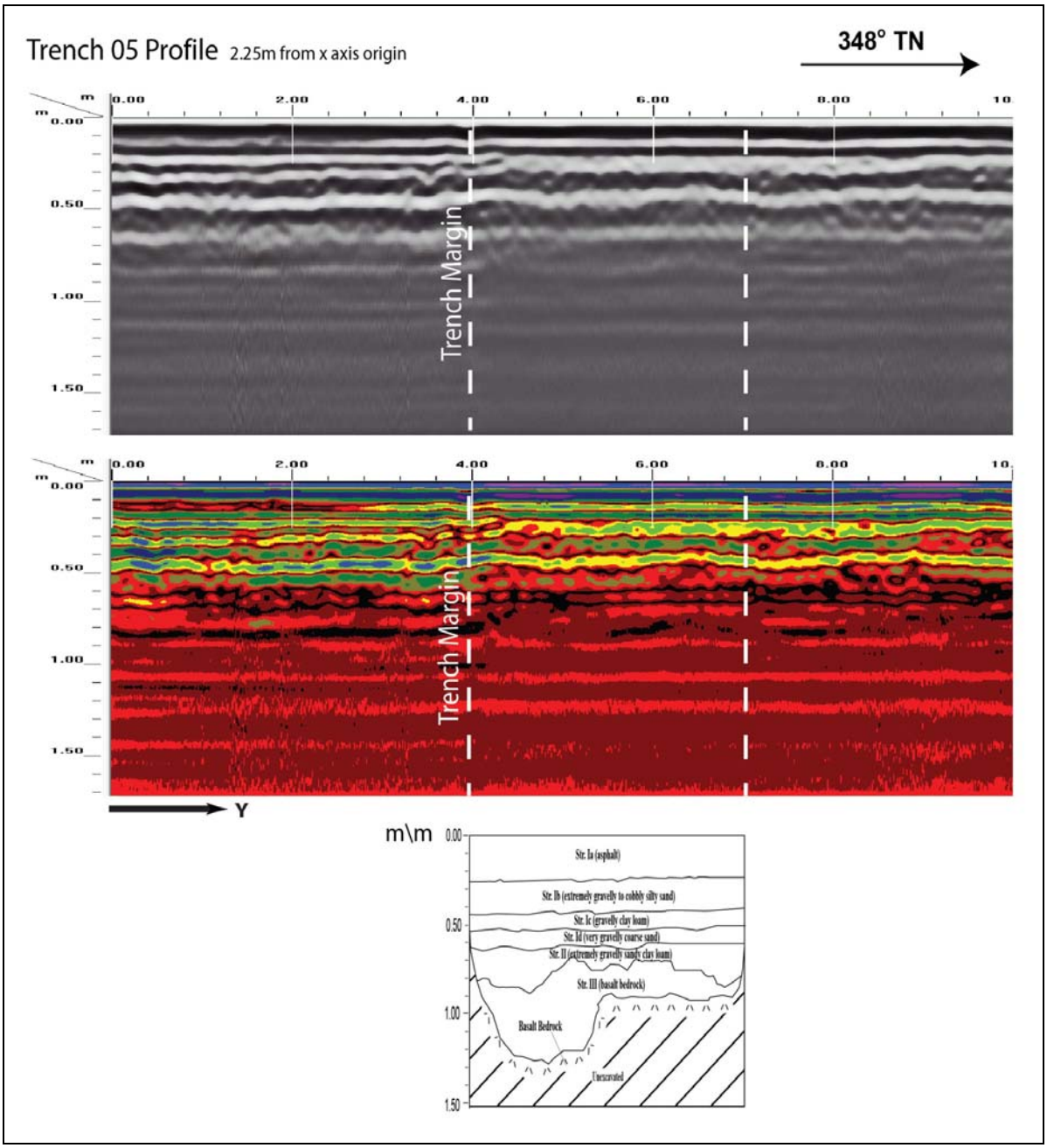

Figure 56. Visual comparison of excavated profile and GPR signal profile of Excavation 05

Excavation 06

Excavation 06 measured 0.6 meters by 6 meters and was oriented North to South and was located within the road cut of Kamehameha Highway 12 meters North of the intersection of Radford Drive on the East side of the median and within the far left lane of the highway.The Makalapa Naval Station was located approximately 23 meters to the East of the excavation. The GPR grid measured 2.5 meters by 9 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: Sewer line 1 meter to the West and a Telecom line 2 meters to the East. No utilties transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 57).

GPR depth profiles for Excavation 06 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 58). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 75 cmbs.

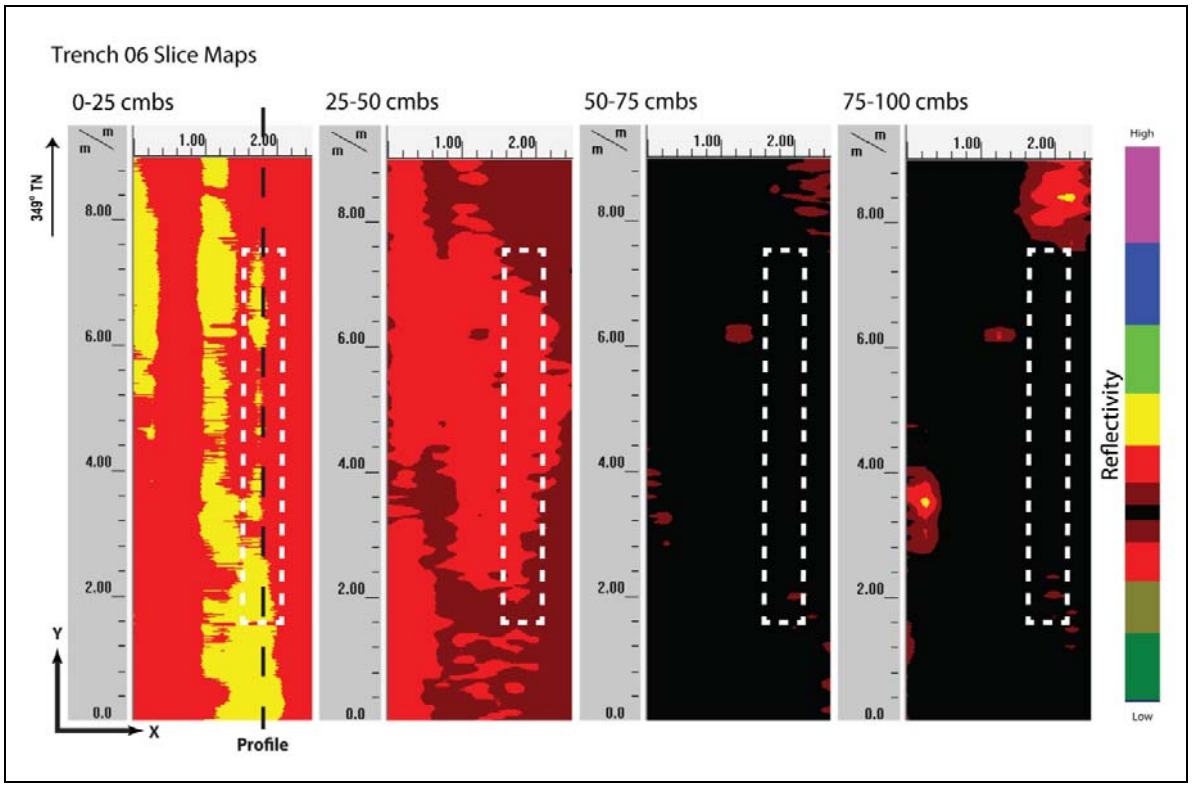

Figure 57. Slice maps of Excavation 06 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 58). The transition from stratum Ia to Ib is clearly observed. Stratum Ib has very low reflectivity which may be attributed the low density crushed coral sand. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

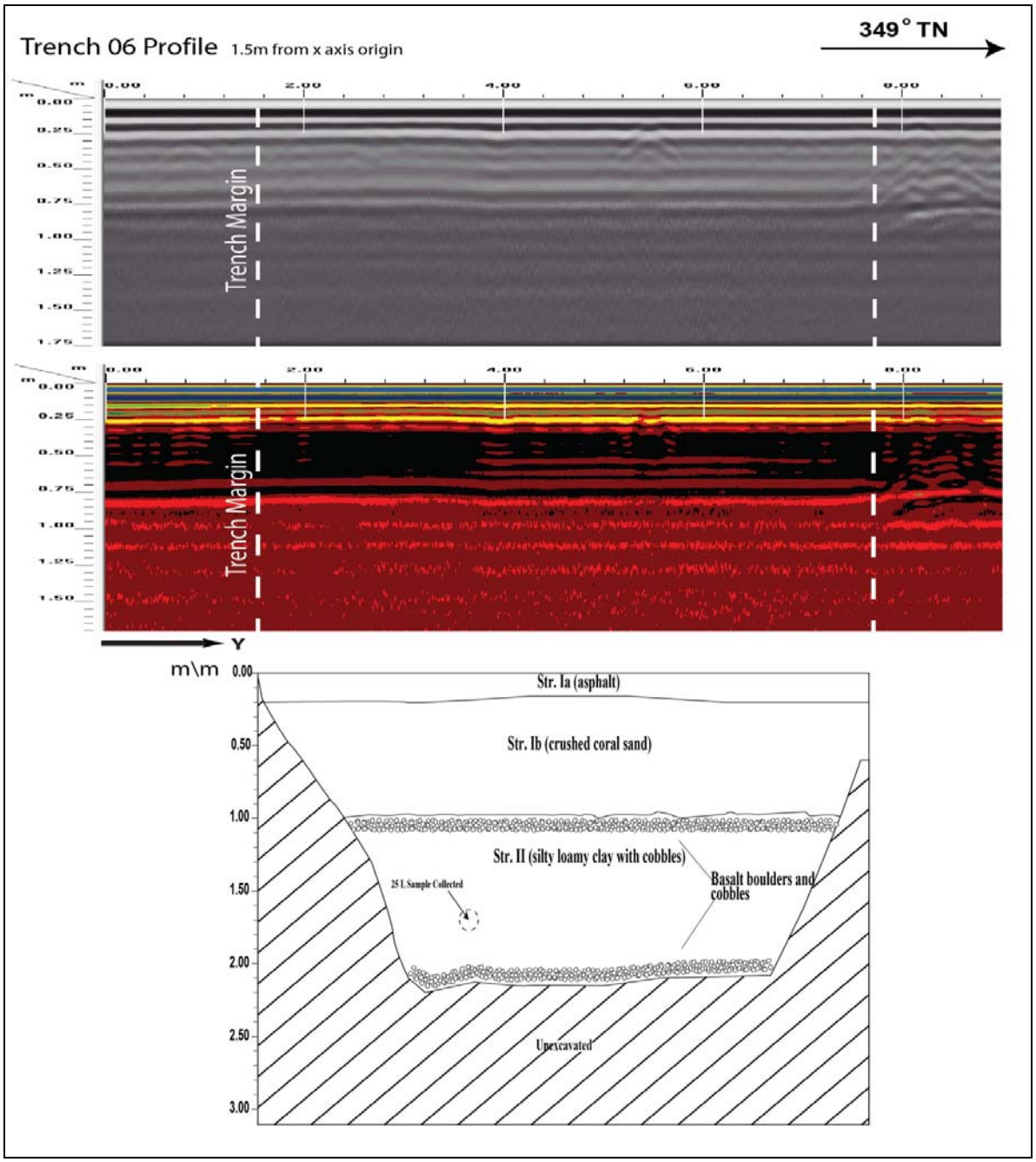

Figure 58. Visual comparison of excavated profile and GPR signal profile of Excavation 06

Excavation 07

Excavation 07 measured 0.6 meters by 6 meters and was oriented Northeast to Southwest and was located within a landscaped area under a large Acacia tree to the Southeast of the intersection of Kamehameha Highway and Radford Drive. Pearl Harbor Kai Elementary School was 55 meters to the West of the excavation. The GPR grid measured 5 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines 4 meters West, 5 meters to the South, and 12 meters to the North, a telecommunication line 8 meters to the Northeast, and a drain line 11 meters to the West. A 2.5” PVC pipe was encountered 30 cmbs on the southern edge of the excavation.

A review of amplitude slice maps does not clearly indicate any linear features although a utility was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 59).

GPR depth profiles for Excavation 07 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 60). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. A utility was observed during excavation but was not clearly defined in the profile. The maximum depth of clean signal return was approximately 110 cmbs.

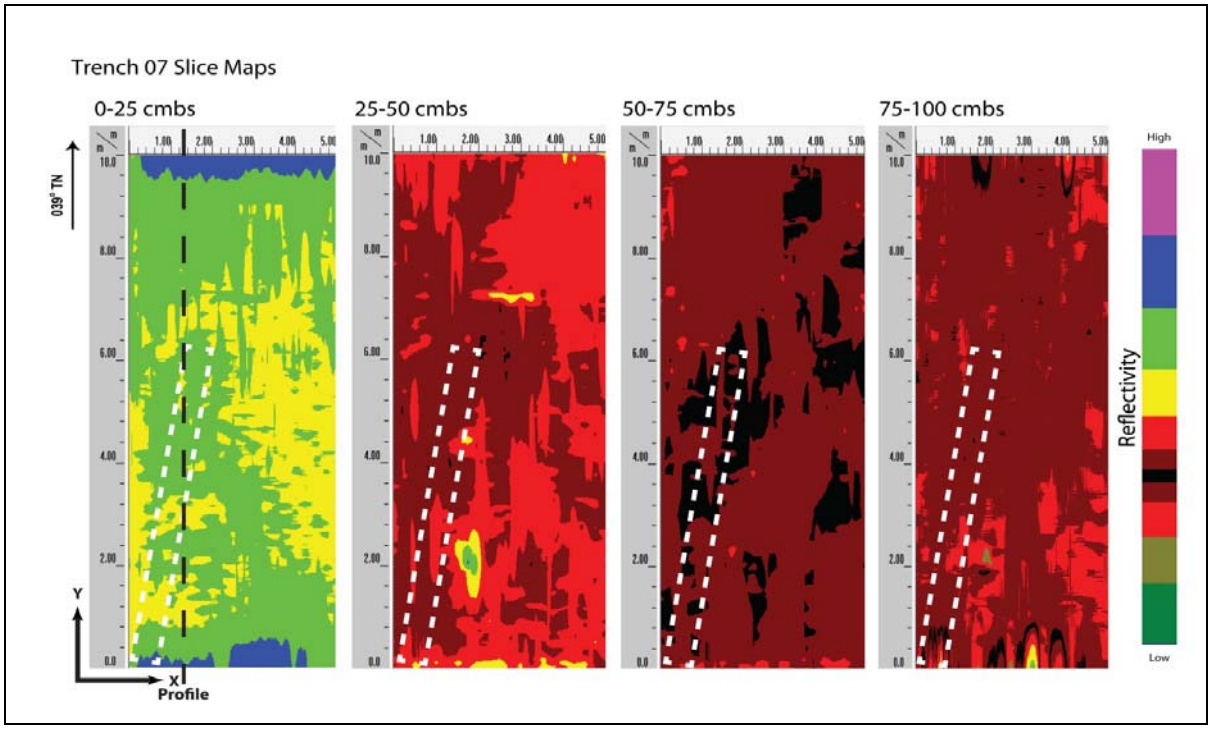

Figure 59. Slice maps of Excavation 07 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 60). Strata included a thin layer of top soil on top of an imported fill layer that continued to 240 cmbs. This was well beyond the maximum depth of clean signal return. A 2.5" PVC pipe was located at around 30 cmbs paralleling the southern edge of the excavation. This corresponded with a small anomaly at this location on the profile map, but it was very difficult to interpret as such. The lack of a clean hyperbola may be a result of the pipe being empty and no clear trench boundaries are present. The pipe is marked on the slice map. No other subsurface features within the signal range were present.

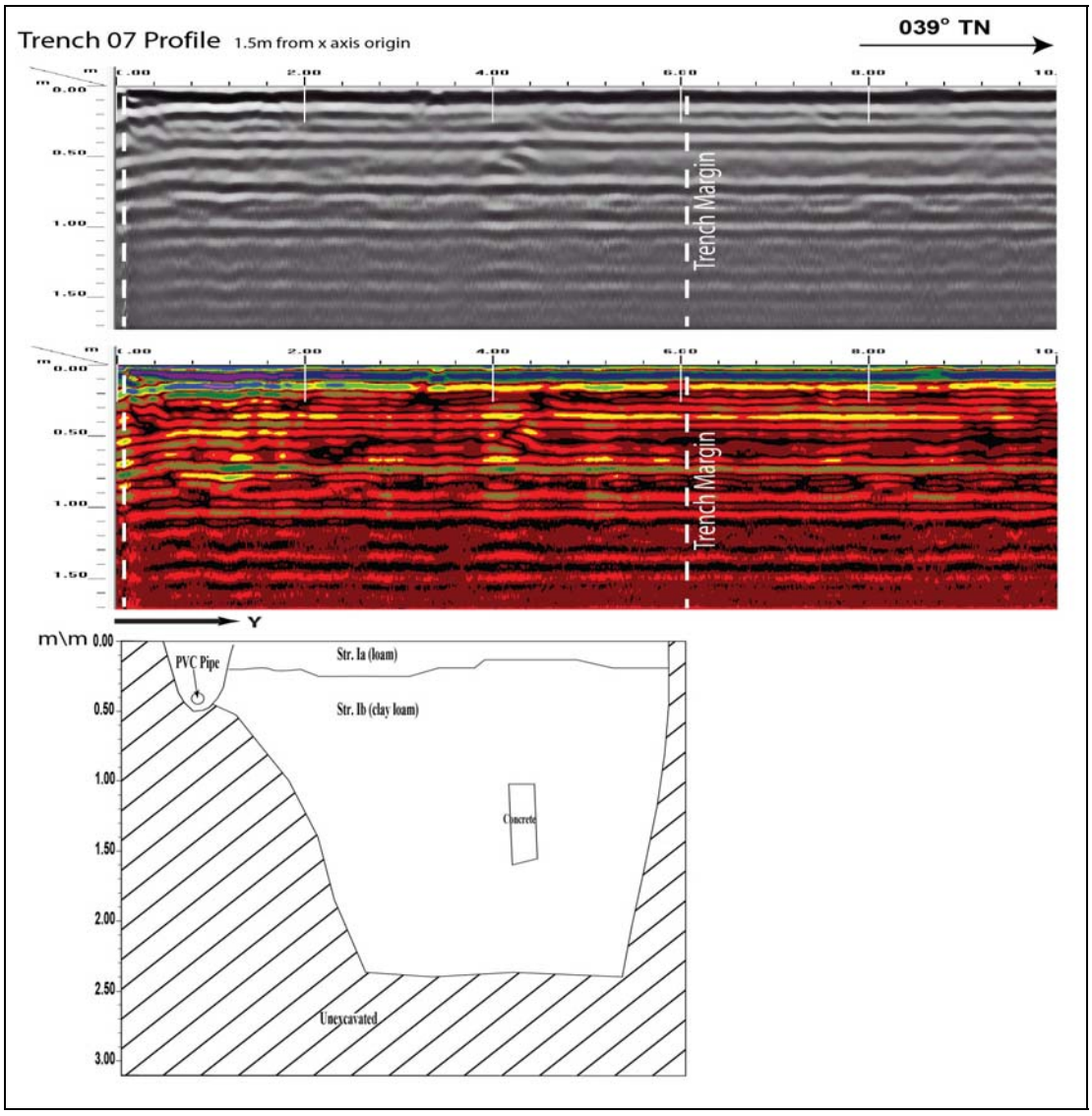

Figure 60. Visual comparison of excavated profile and GPR signal profile of Excavation 07

Excavation 08

Excavation 08 measured 0.6 meters by 6 meters and was oriented North to South and was located within a landscaped area near a large Acacia tree to the Southeast of the intersection of Kamehameha Highway and Radford Drive. Pearl Harbor Kai Elementary School was 76 meters to the West of the excavation. The GPR grid measured 5 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: Sewer line 7 meters to the North and an unknown utility 3 meters to the North. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 61).

GPR depth profiles for Excavation 08 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 62). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 110 cmbs.

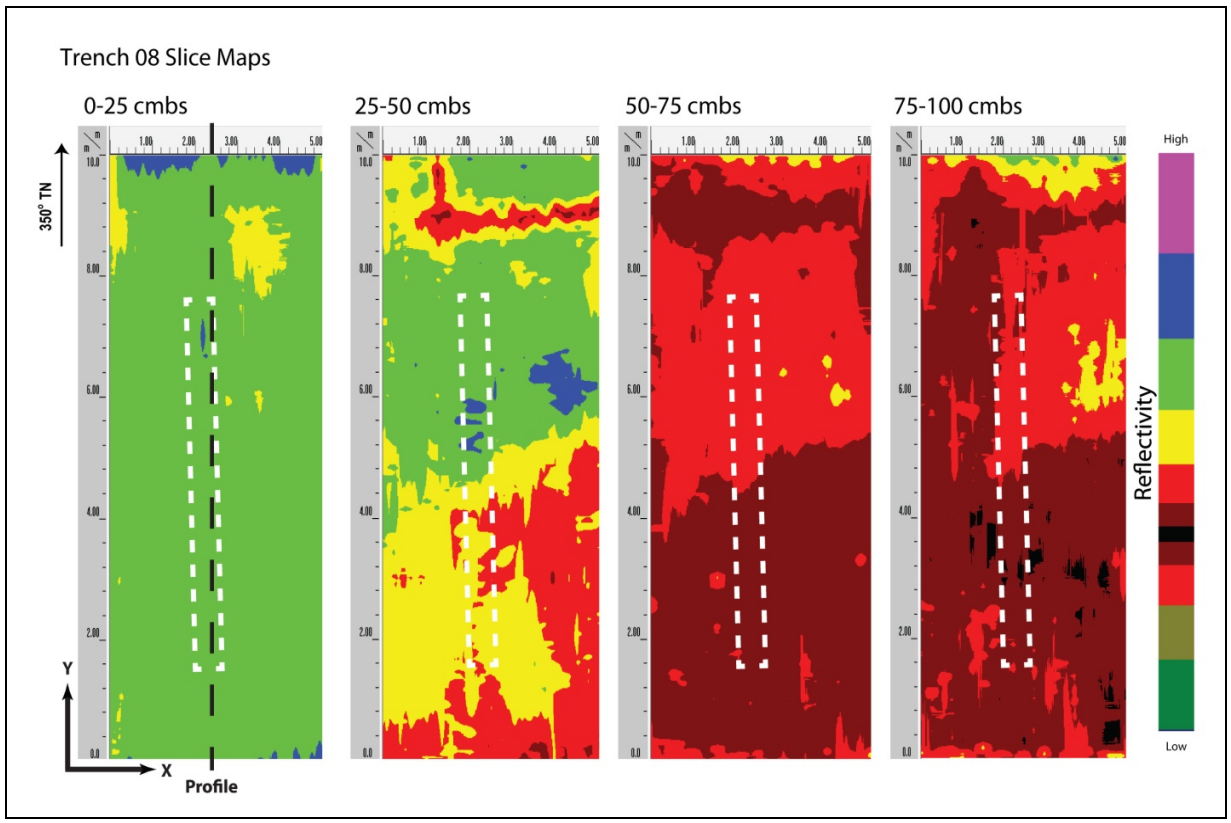

Figure 61. Slice maps of Excavation 08 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 62). The transition from stratum Ia to Ib is clearly observed. Stratum Ib has a low reflectivity which may be attributed the lower density sand. Stratum IIa displayed higher reflectivity and may represent the chemical composition of the basaltic bedrock. No discrete objects were observed in the GPR results or subsequent excavation.

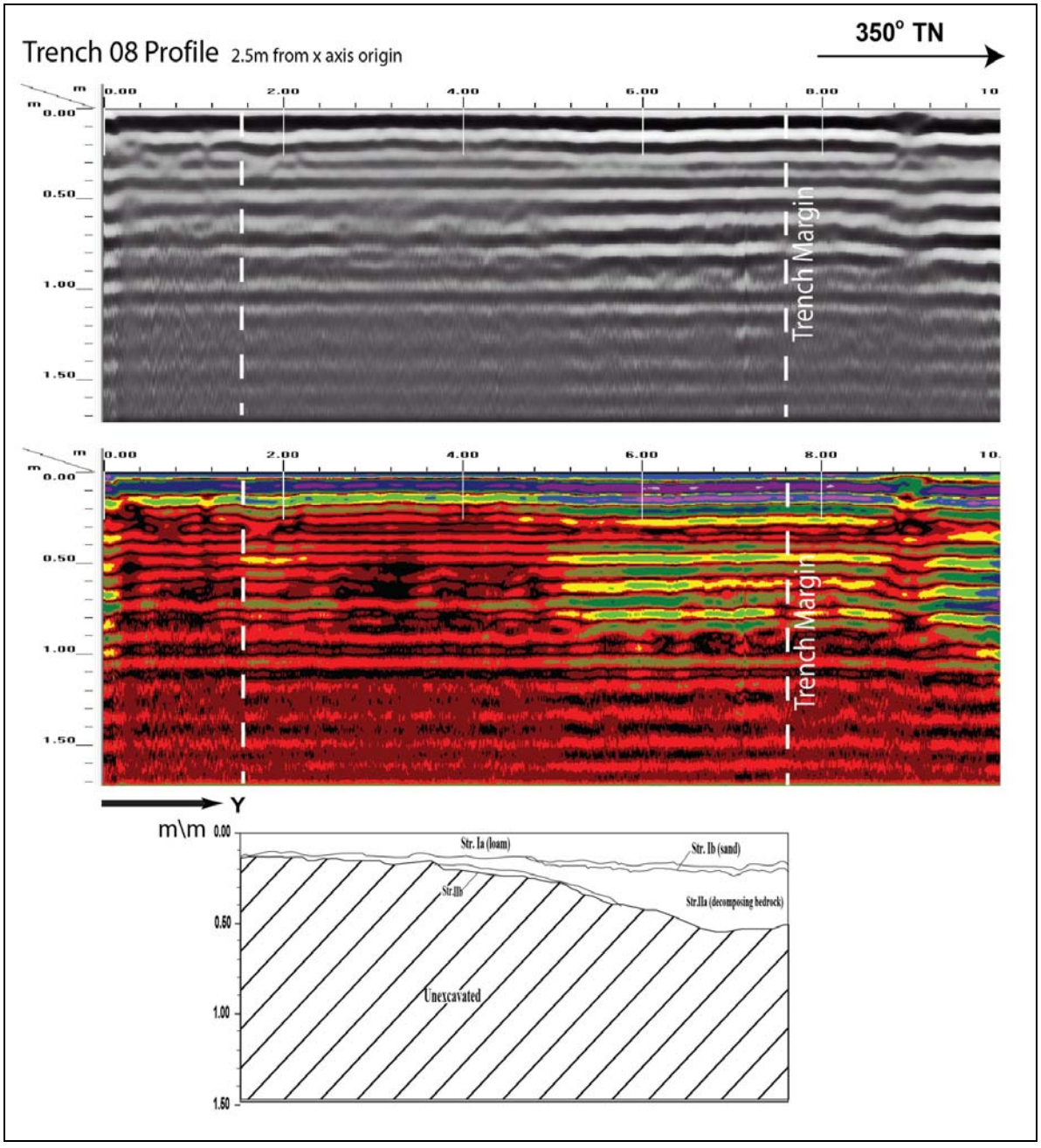

Figure 62. Visual comparison of excavated profile and GPR signal profile of Excavation 08

Excavation 09

Excavation 09 measured 0.6 meters by 6 meters and was oriented Northeast to Southwest and was located within a landscaped area near a large Acacia tree to the Southeast of the intersection of Kamehameha Highway and Radford Drive. Pearl Harbor Kai Elementary School was 50 meters to the West of the excavation. The GPR grid measured 5 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: sewer line 1 meter to the South and a water line running North to South through the Northeastern end of the excavation. A 2.5” PVC water line was encountered 30 cmbs on the Northeast end of the excavation.

A review of amplitude slice maps does not clearly indicate any linear features although a utility was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 63).

GPR depth profiles for Excavation 09 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 64). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. A utility was encountered during excavation but was not observed in the profile. The maximum depth of clean signal return was approximately 110 cmbs.

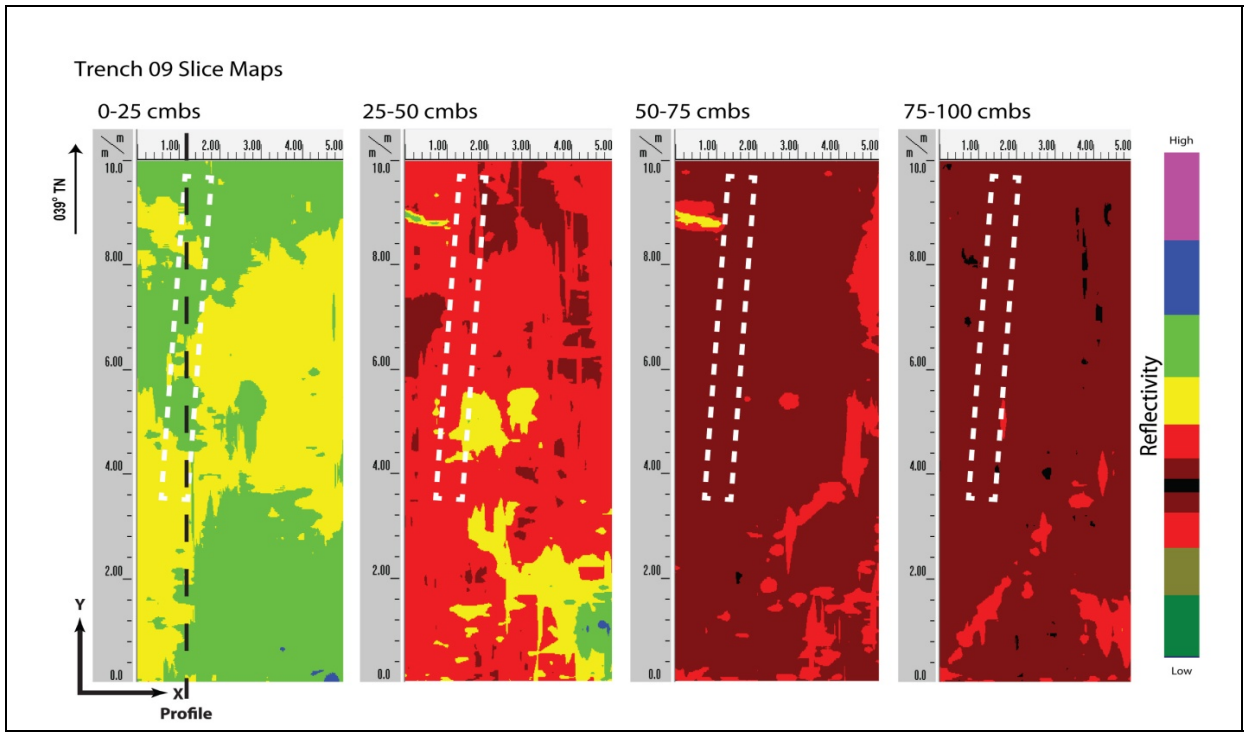

Figure 63. Slice maps of Excavation 09 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a weak correlation in stratigraphic transitions (Figure 64). Stratum included a thin layer of top soil on top of basaltic gravel followed by solid basaltic bedrock. These transitions were not clearly depicted in the GPR profile at the depths that they occured. A 2.5" PVC pipe was located at about 30 cmbs. This pipe did not show up on the profile or slice maps. This may be due to the fact that the pipe was empty and no clearly defined excavation boundaries were present. No other discrete objects were observed in the GPR results or subsequent excavation.

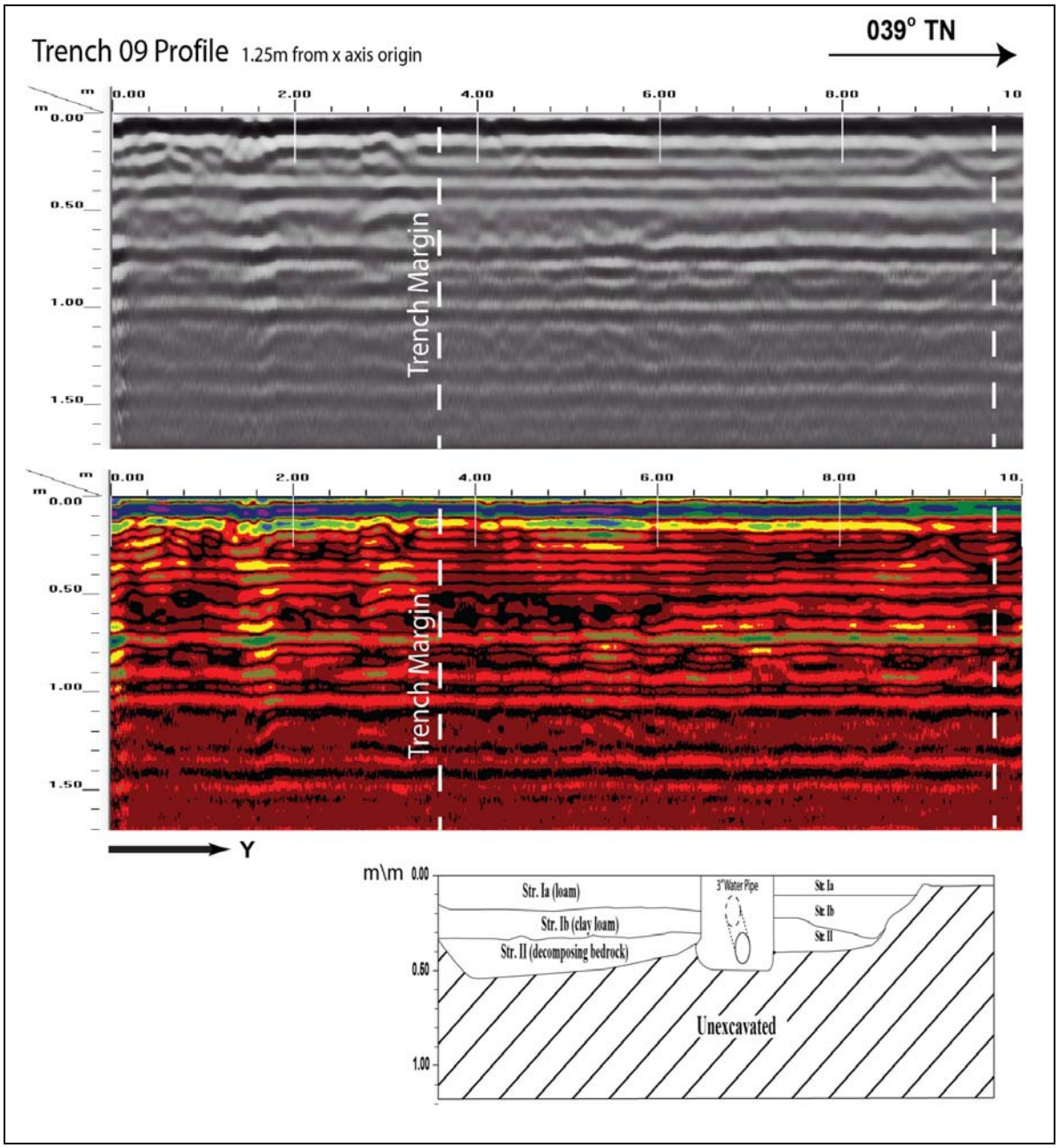

Figure 64. Visual comparison of excavated profile and GPR signal profile of Excavation 09

Excavation 10

Excavation 10 measured 0.6 meters by 6 meters and was oriented North to South and was located within a landscaped area near a large Acacia tree to the Southeast of the intersection of Kamehameha Highway and Radford Drive. Pearl Harbor Kai Elementary School was 95 meters to the West of the excavation. The GPR grid measured 5 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: sewer line 13 meters to the North and an unknown utility 11 meters to the North. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 65).

GPR depth profiles for Excavation 10 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 66). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 110 cmbs.

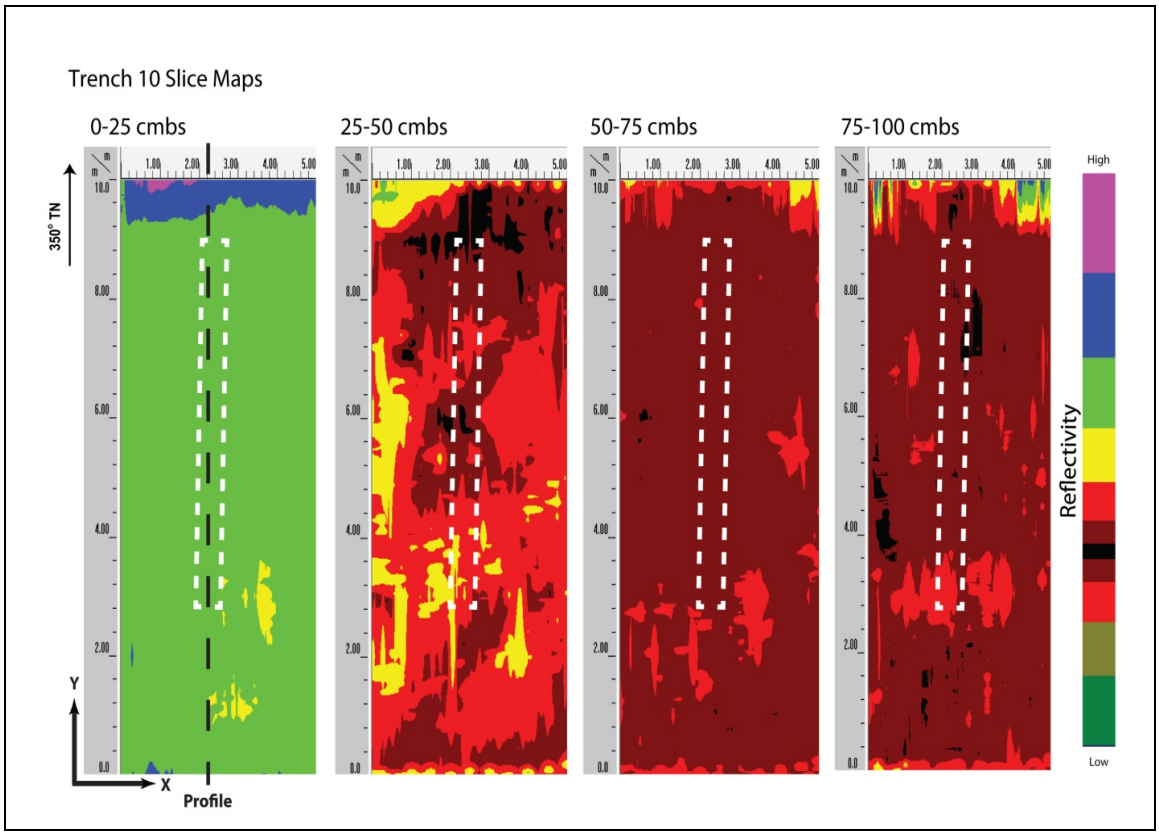

Figure 65. Slice maps of Excavation 10 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 66). The transition from stratum Ia to IIa is clearly observed. Stratum IIa has low reflectivity which may be attributed the lower density basalt gravel sand. No discrete objects were observed in the GPR results or subsequent excavation.

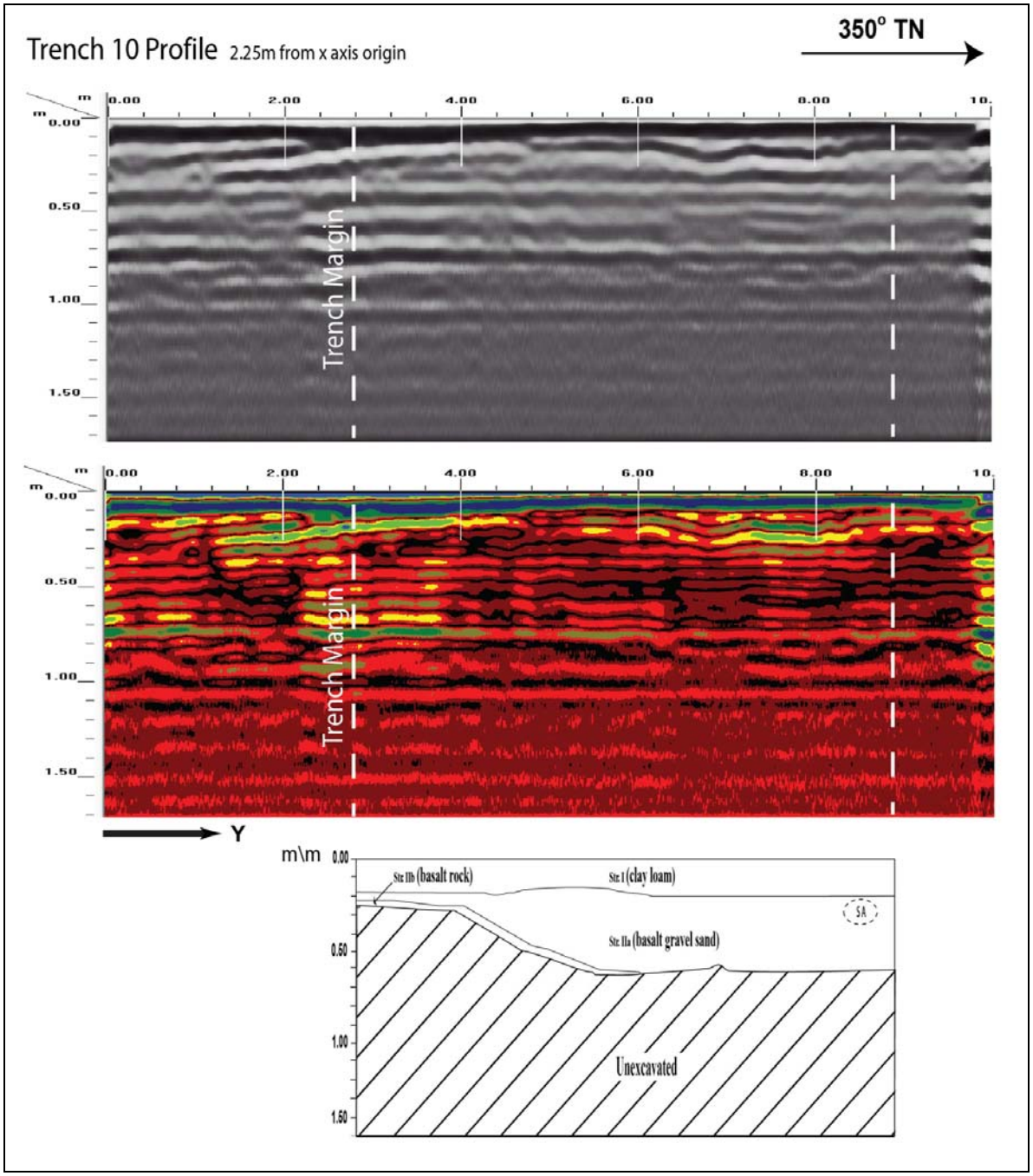

Figure 66. Visual comparison of excavated profile and GPR signal profile of Excavation 10

Excavation 11

Excavation 11 measured 0.6 meters by 6 meters and was oriented East to West and was located within a landscaped area near a large Acacia tree to the Southeast of the intersection of Kamehameha Highway and Radford Drive. Pearl Harbor Kai Elementary School was 57 meters to the West of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: communication lines 7 meters to the East and 14 meters to the South, sewer line 6 meters to the North and an unknown utility running Northeast to Southwest and going through the Eastern end of the excavation. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 67).

GPR depth profiles for Excavation 11 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 68). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 110 cmbs.

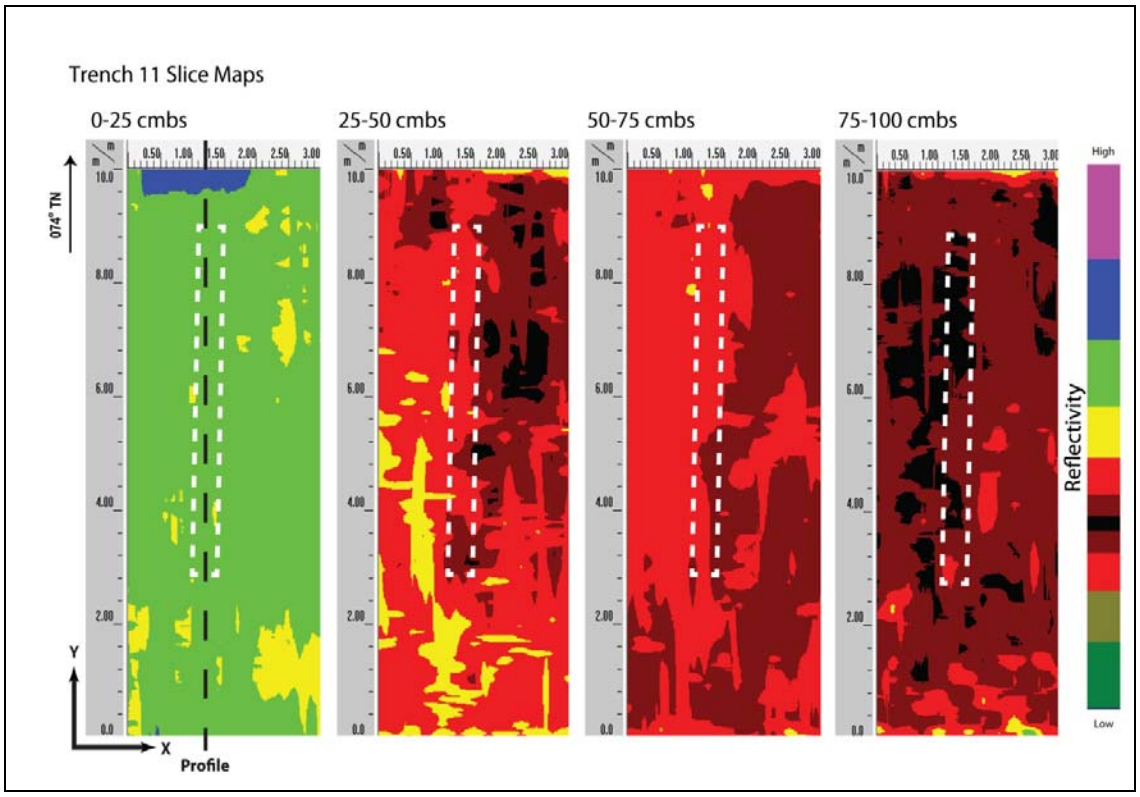

Figure 67. Slice maps of Excavation 11 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a weak correlation in stratigraphic transitions (Figure 68). Stratum included a thin layer of clay loam on top of basaltic ash followed by solid basaltic bedrock. These transitions were not clearly depicted in the GPR profile at the depths that they occured. No other sediment transitions or discrete objects were observed in the GPR results or subsequent excavation.

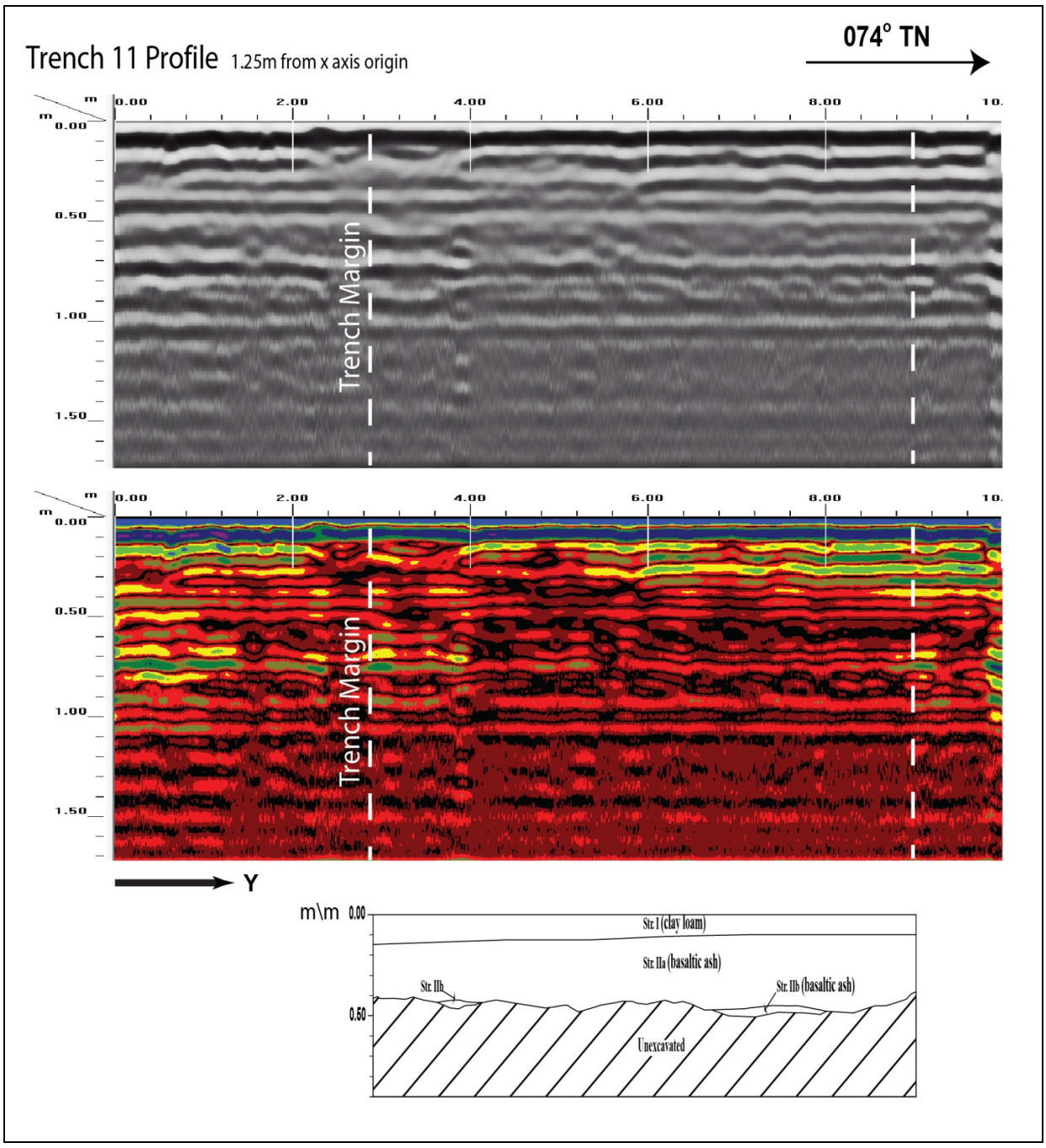

Figure 68. Visual comparison of excavated profile and GPR signal profile of Excavation 11

Excavation 12

Excavation 12 measured 0.9 meters by 3 meters and was oriented North to South and was located within the median of Kamehameha Highway 35 meters North of the intersection of Center Drive. The Mall at Pearl Harbor was located approximately 200 meters to the East of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: gas line 3.5 meters to the East and a communication line 8 meters to the West. No utilties transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 75 cmbs (Figure 69).

GPR depth profiles for Excavation 12 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 70). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 75 cmbs.

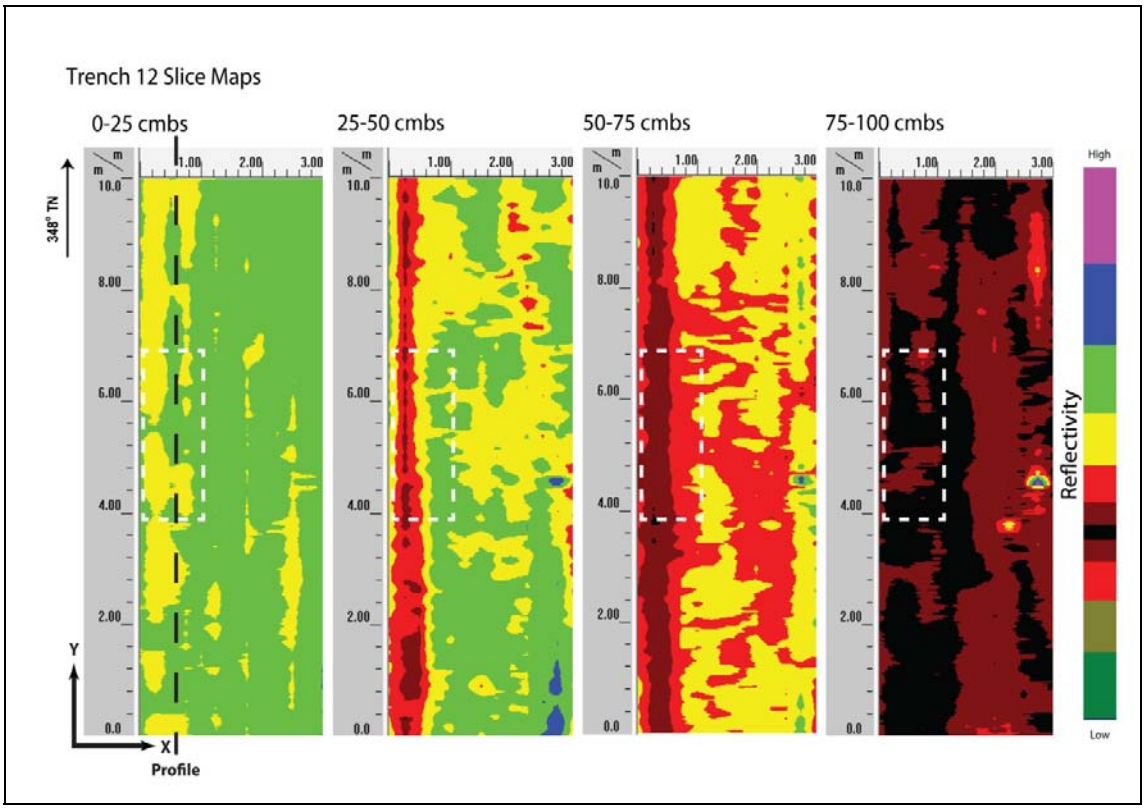

Figure 69. Slice maps of Excavation 12 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 70). Strata Ia to II are all clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas are apparent in the crushed coral strata. The parallel utility located in the western edge at 68 cmbs was not clearly depicted in the GPR profile. No other discrete objects or sediment transitions were observed in the GPR results or subsequent excavation

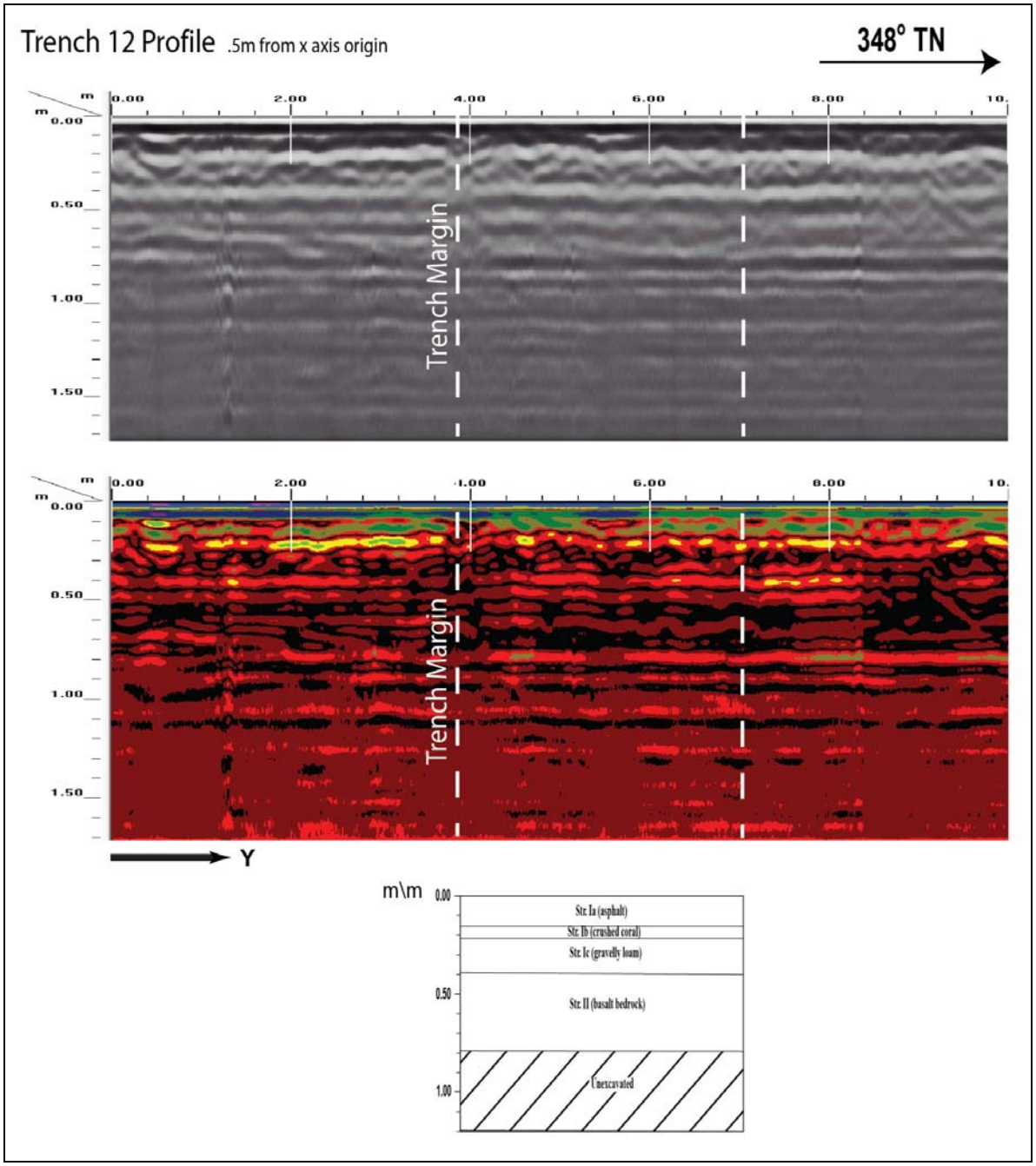

Figure 70. Visual comparison of excavated profile and GPR signal profile of Excavation 12

Excavation 13

Excavation 13 measured 0.9 meters by 3 meters and was oriented North to South and was located within the median and 24 meters South of the Kamehameha Highway split between Hickam AFB and Nimitz Highway. Joint Base Pearl Harbor-Hickam was located approximately 170 meters Northwest of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water line .5 meters to the South, a drain line 2 meters to the North and an electric line 1.5 meters to the East. A 1.5” PVC utility was encountered 20 cmbs on the Northern end of the excavation.

A review of amplitude slice maps does not clearly indicate any linear features although a utility and tree root were encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25-50 cmbs (Figure 71).

GPR depth profiles for Excavation 13 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 72). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 35 cmbs. Two anomalies were indicated on the profile which corresponded to the tree root and utility encountered during excavation. The maximum depth of clean signal return was approximately 100 cmbs.

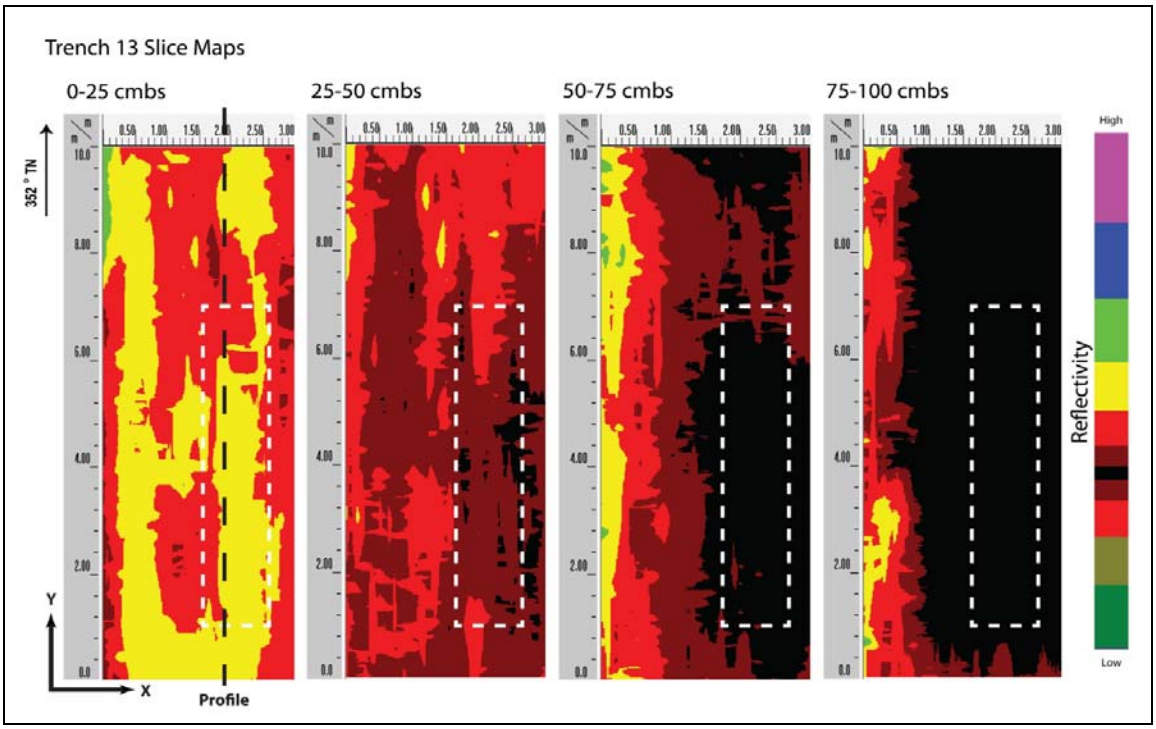

Figure 71. Slice maps of Excavation 13 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a very strong correlation in stratigraphic transitions (Figure 72). Strata Ia and Ib are all clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ib which was extremely cobbly sandy loam. A large tree root located in southern edge of the excavation and a 1.5” utility pipe located in the northern edge of the excavation are clearly shown in the profile. All other sediment transitions are below the maxium depth of clean signal return. No other discrete objects were observed in the GPR results or subsequent excavation.

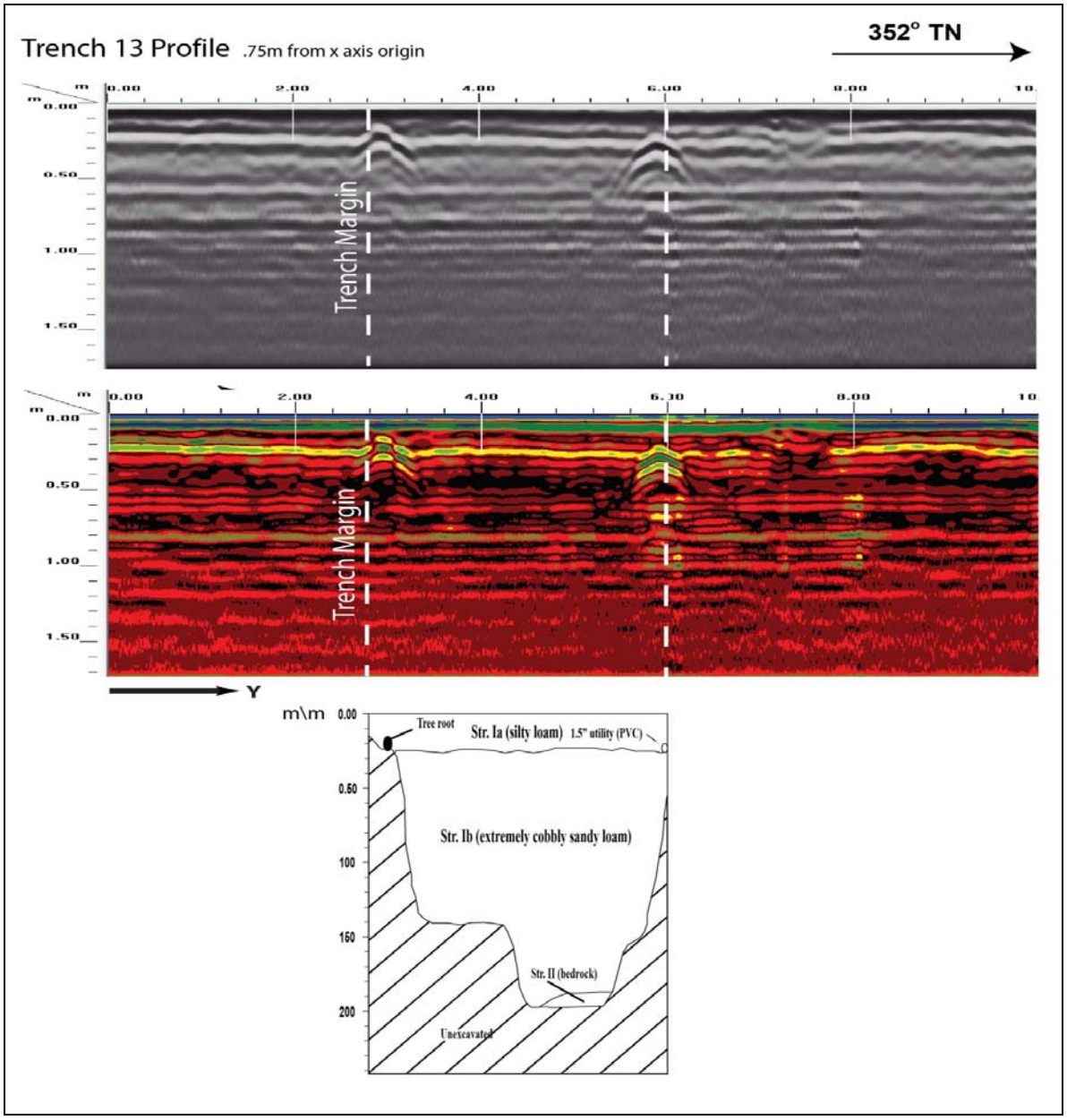

Figure 72. Visual comparison of excavated profile and GPR signal profile of Excavation 13

Excavation 14

Excavation 14 measured 0.9 meters by 3 meters and was oriented Northeast to Southwest and was located within a landscaped median under a tree between H1 Freeway and Nimitz Highway on ramp, 6 meters East of Makai Frontage Road. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: Communication line 2 meters to the West, Water lines 2 meters to the West and 11 meters to the East. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs and increases again at 75 cmbs (Figure 73).

GPR depth profiles for Excavation 14 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 74). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs and again around 60 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 125 cmbs.

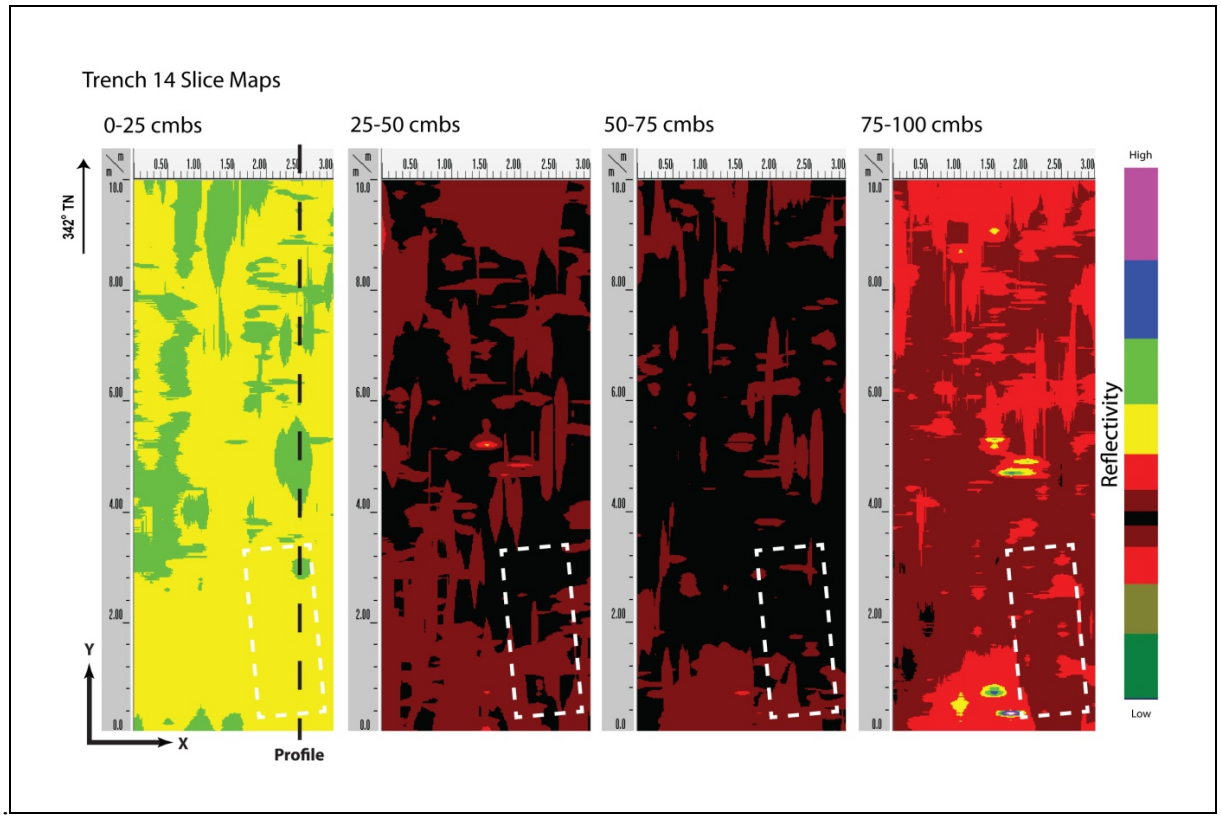

Figure 73. Slice maps of Excavation 14 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 74). Strata Ia to Ib are all clearly observed and occur near the ground-truthed depths. An increase in reflectivity is observed around 80 cmbs and may represent gravelly cobbly sandy loam located at this depth. No discrete objects or other stratigraphic transitions were observed in the GPR results or subsequent excavation.

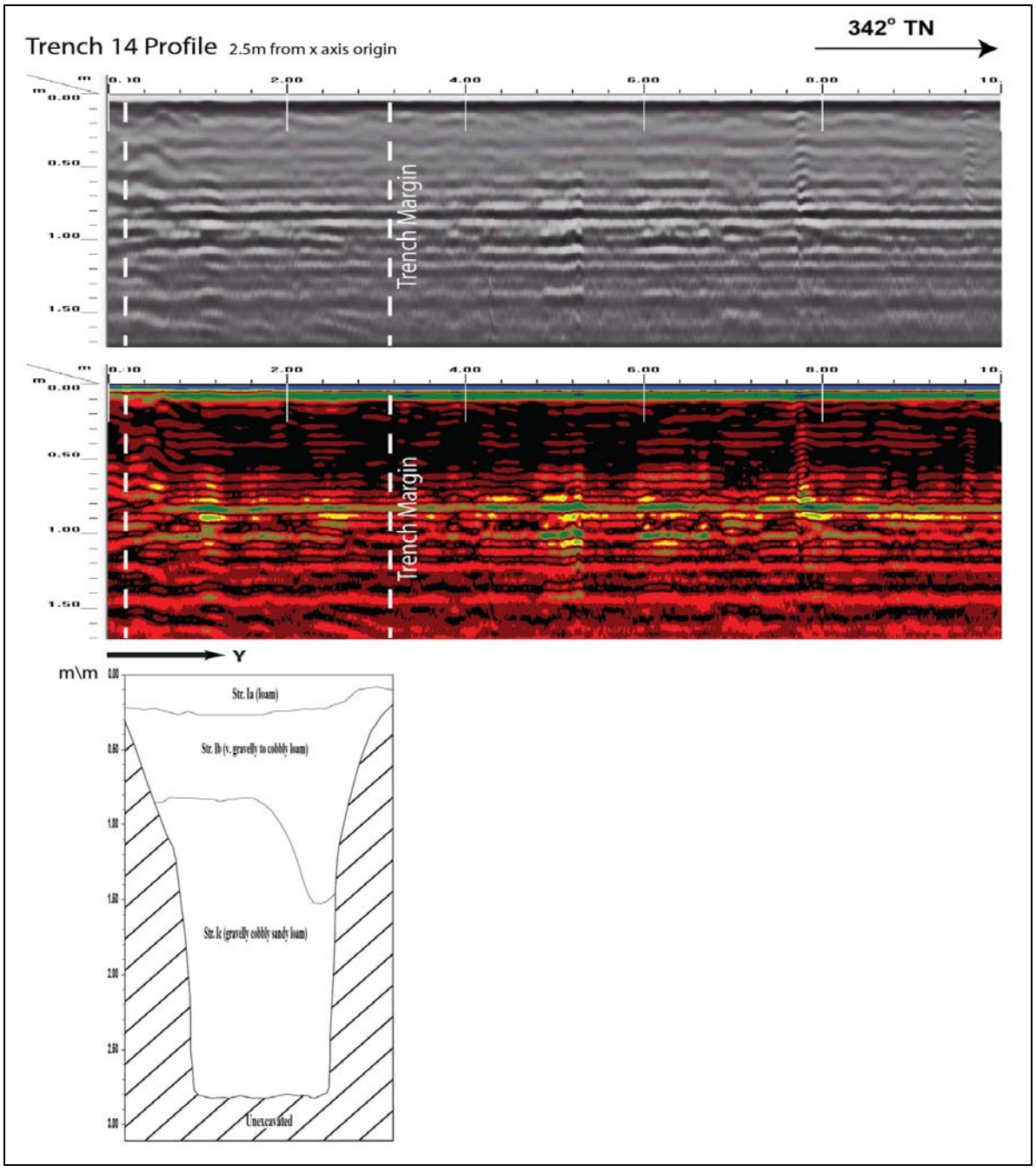

Figure 74. Visual comparison of excavated profile and GPR signal profile of Excavation 14

Excavation 15

Excavation 15 measured 0.9 meters by 3 meters and was oriented East to West and was located within a landscaped median between Makai Frontage Road and H1 Freeway and 7 meters North of the Ramp WN overpass. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines 7 meters to the East and 8 meters to the West, communication line 6 meters to the East and a power line 9.5 meters to the West. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 75).

GPR depth profiles for Excavation 15 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 76). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs and again around 75 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 125 cmbs.

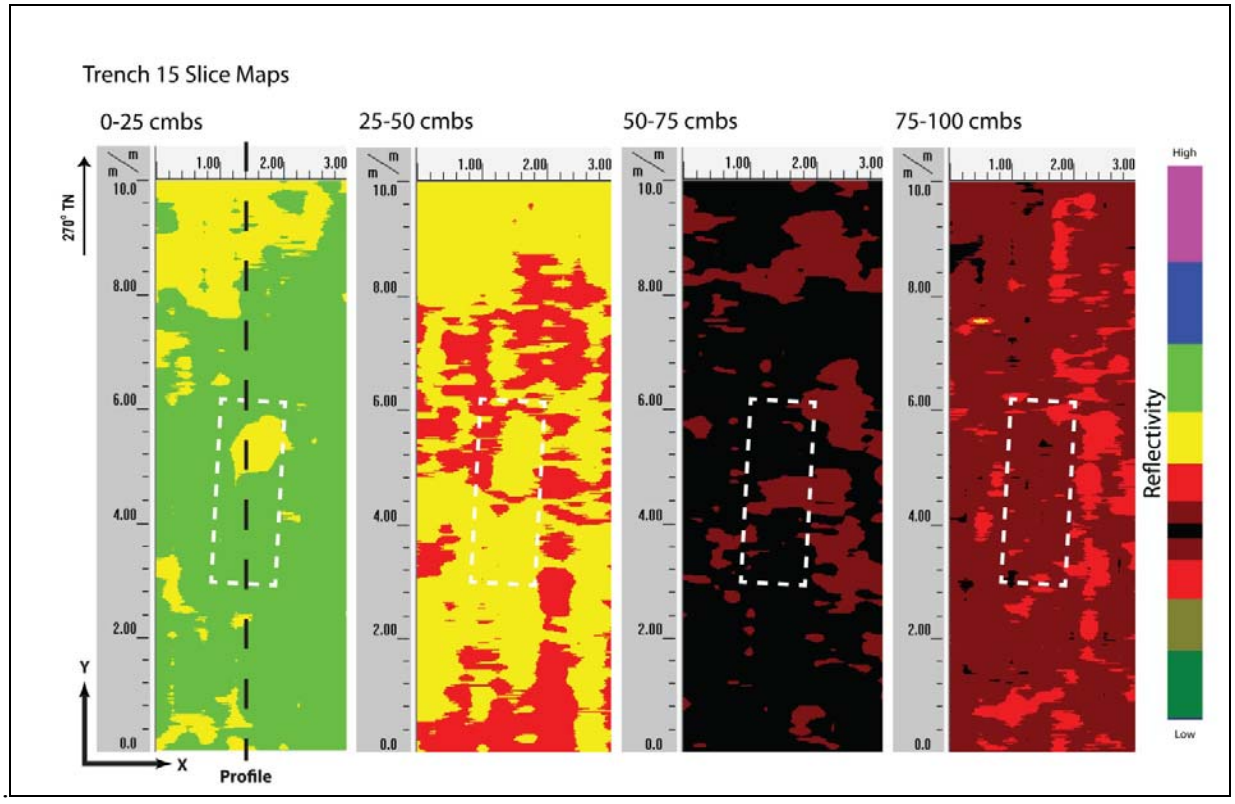

Figure 75. Slice maps of Trench 15 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 76). Strata Ib and Ic are clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ic which was extremely cobbly sandy silt. No discrete objects were observed in the GPR results.

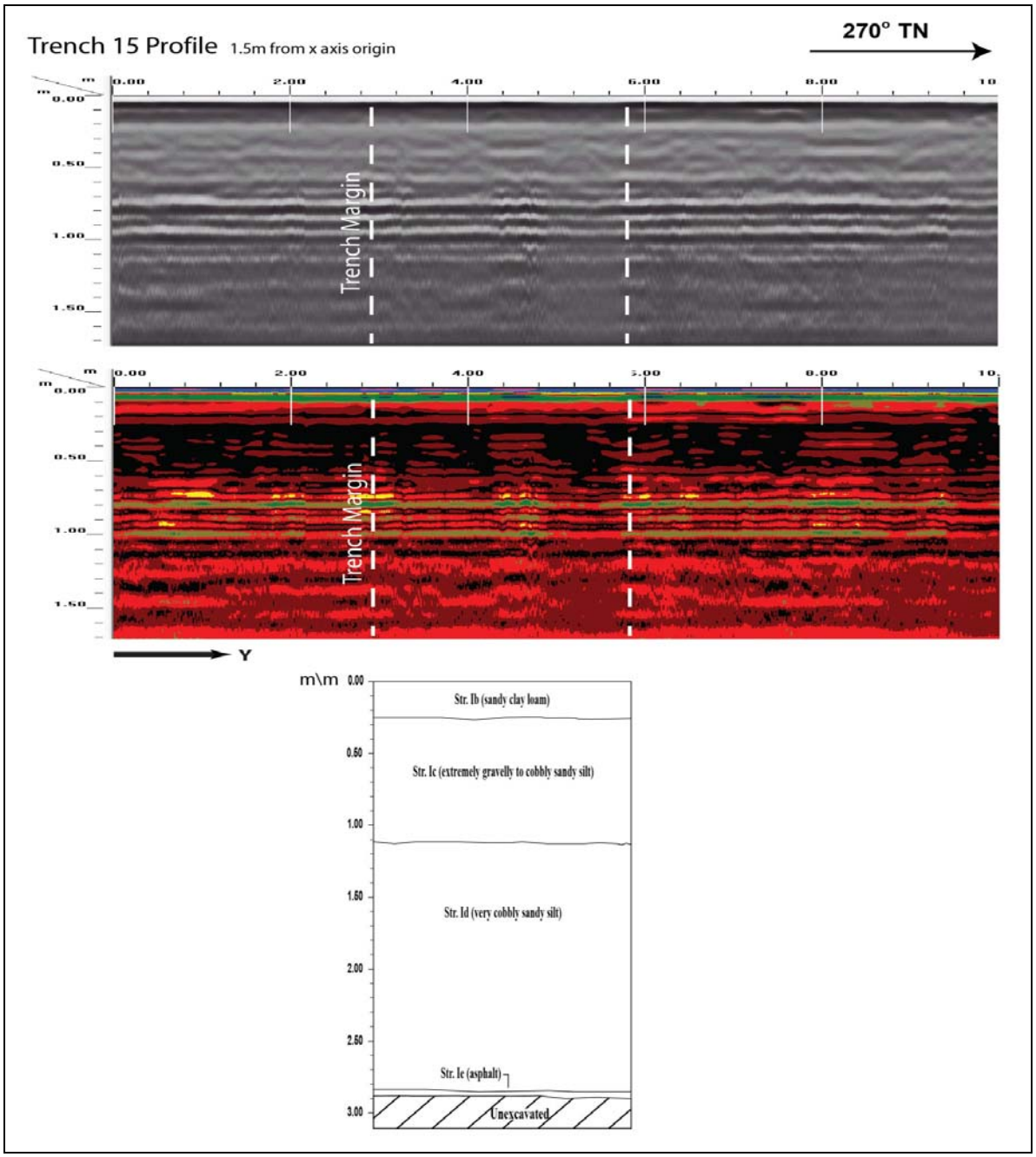

Figure 76. Visual comparison of excavated profile and GPR profile of Excavation 15

Excavation 16

Excavation 16 measured 0.9 meters by 3 meters and was oriented Northwest to Southeast and was located within a landscaped median between Ramp NE and H1 Freeway approximately 100 meters before the merge. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: power line .5 meters to the Northeast, water line 1 meter to the Northeast and a drain line 7.5 meters to the South. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 77).

GPR depth profiles for Excavation 16 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 78). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

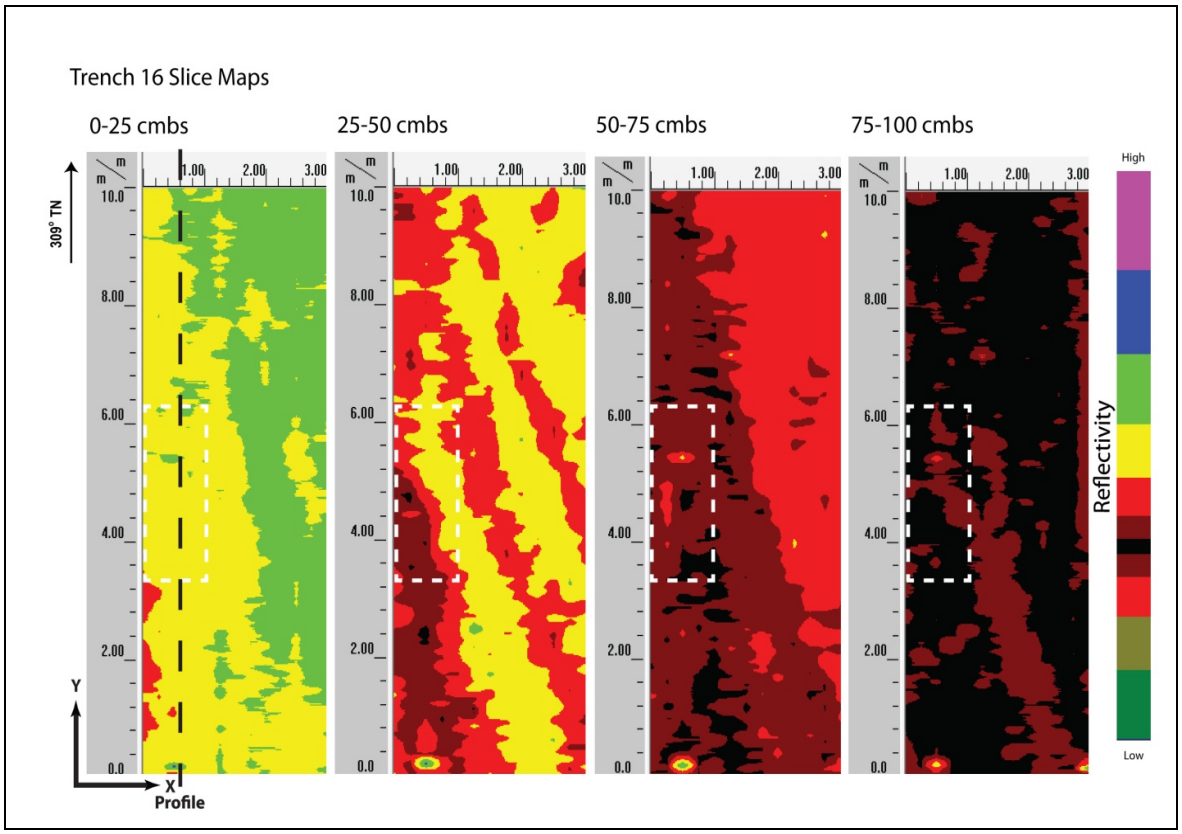

Figure 77. Slice maps of Excavation 16 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 78). Strata Ib and Ic are clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ic which was extremely cobbly sandy silt. No discrete objects were observed in the GPR results.

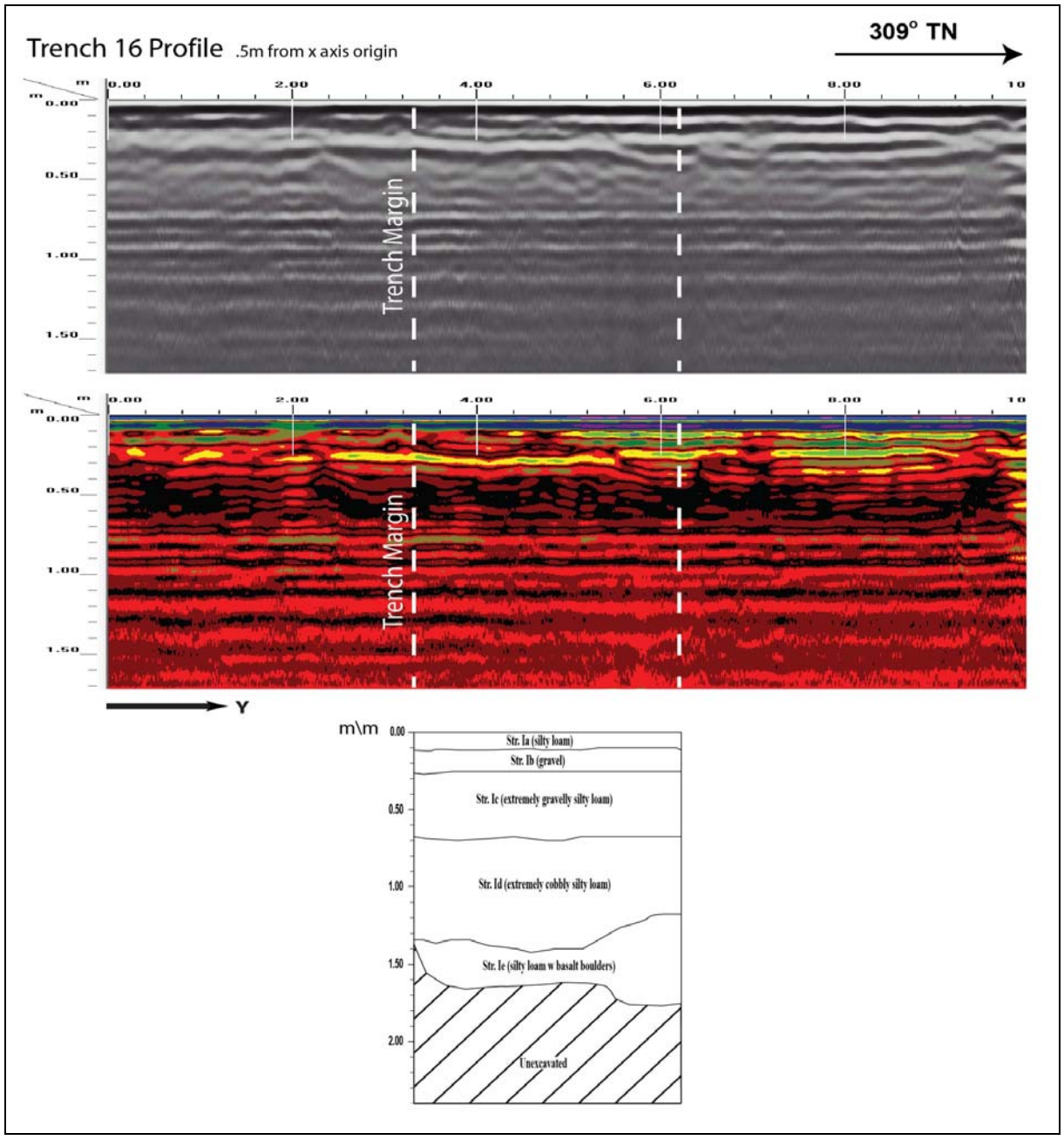

Figure 78. Visual comparison of excavated profile and GPR signal profile of Excavation 16

Excavation 17

Excavation 17 measured 0.9 meters by 3 meters and was oriented East to West and was located within a landscaped area 6 meters to the South of Nimitz Highway 66 meters Northwest of Main Street and 95 meters Southeast of Valkenburgh Street. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines 6 and 15 meters to the Southwest, drain line 9 meters to the Southwest and a communication line 11.5 meters to the Northeast. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 79).

GPR depth profiles for Excavation 17 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 80). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 15 cmbs and again around 80 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 125 cmbs.

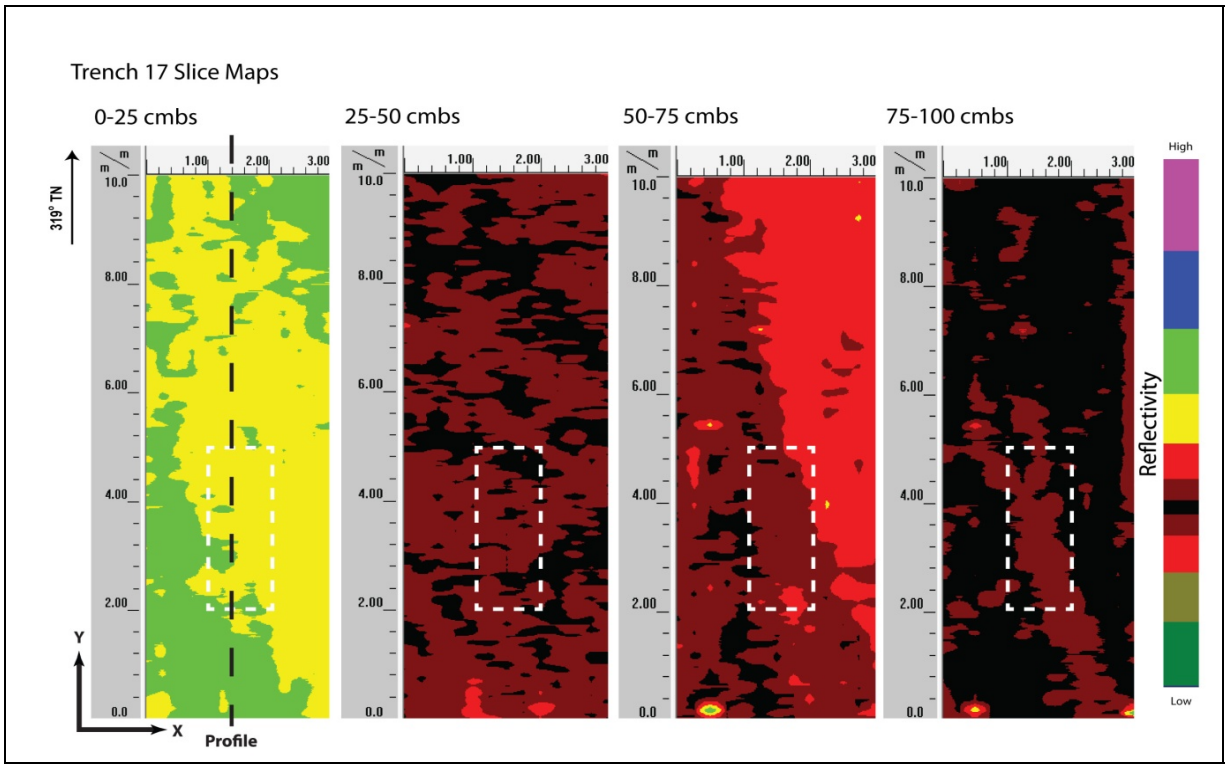

Figure 79. Slice maps of Excavation 17 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 80). Strata Ib and Ic are clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ic which was extremely cobbly sandy silt. No discrete objects were observed in the GPR results.

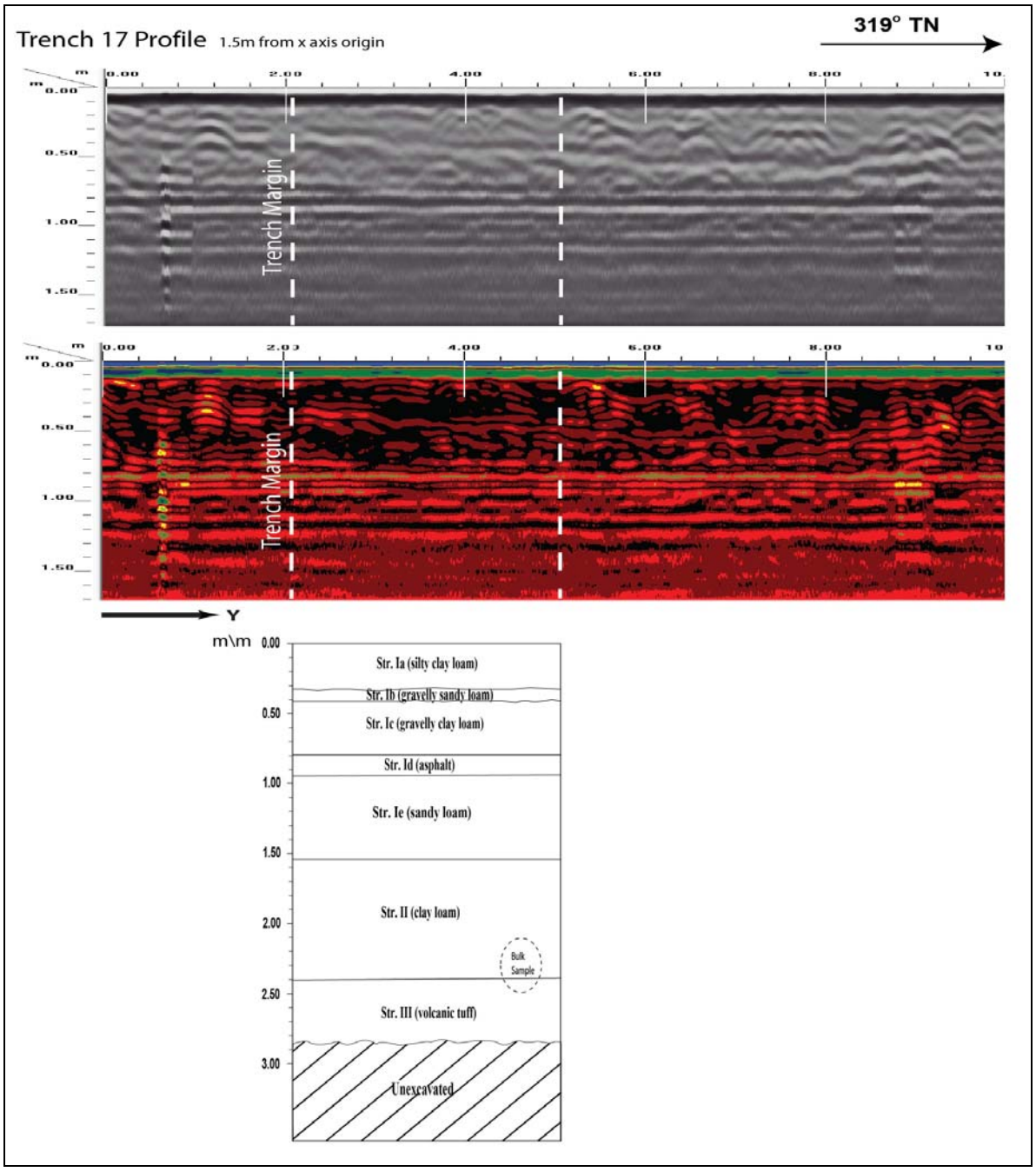

Figure 80. Visual comparison of excavated profile and GPR signal profile of Excavation 17

Excavation 18

Excavation 18 measured 0.9 meters by 3 meters and was oriented Northwest to Southeast and was located within a landscaped area South of Nimitz Highway and approximately 2 meters South of the sidewalk. Elliot Street was approximately 68 meters Southeast and Main Street approximately 114 meters to the Northwest of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain lines 4 meters to the West and 7 meters to the South and a waterline 12 meters to the South. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 81).

GPR depth profiles for Excavation 18 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 82). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

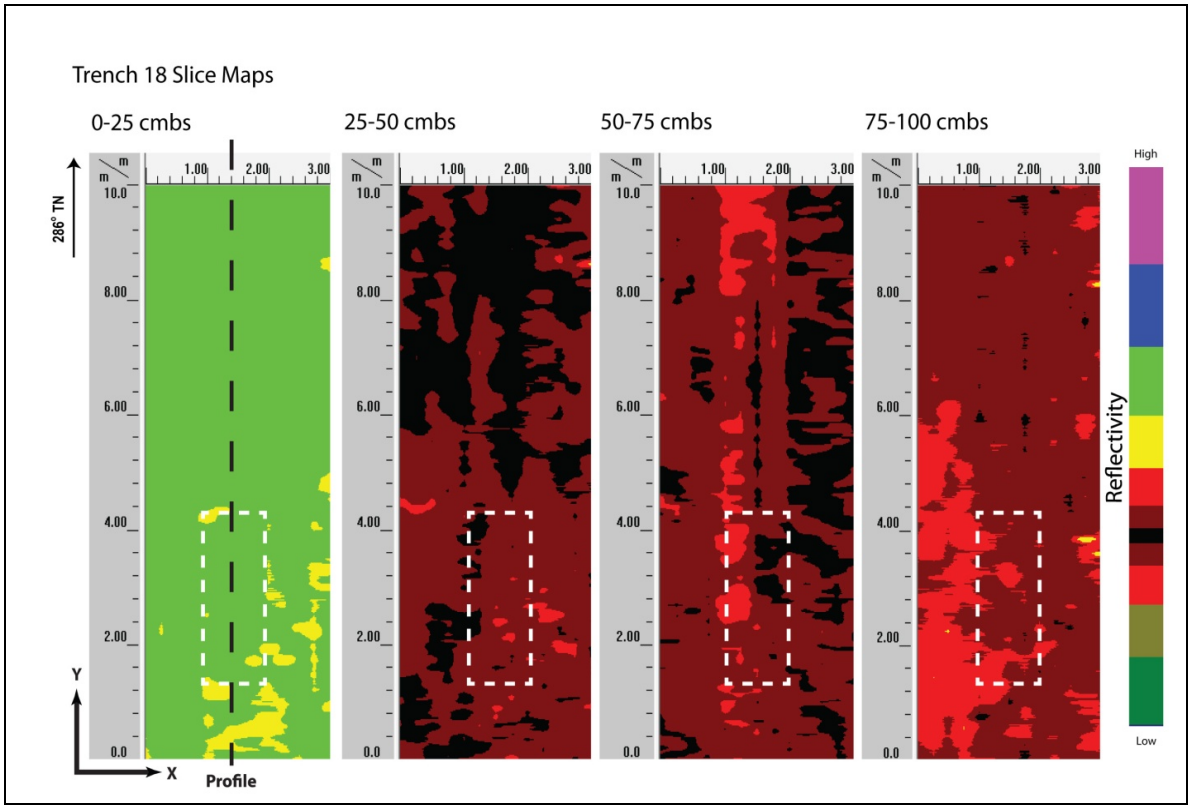

Figure 81. Slice maps of Excavation 18 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 82). Strata Ia and Ib are clearly observed in the GPR profile and occur at the ground-truthed depths. Stratum Ic, which is an asphalt layer, is observed as smooth banding. Stratum Id was a layer of concete and was represented by higher reflectivity and horizontal banding. No other sediment transitions or discrete objects were observed in the GPR results due to loss of clean signal at ~100 cmbs.

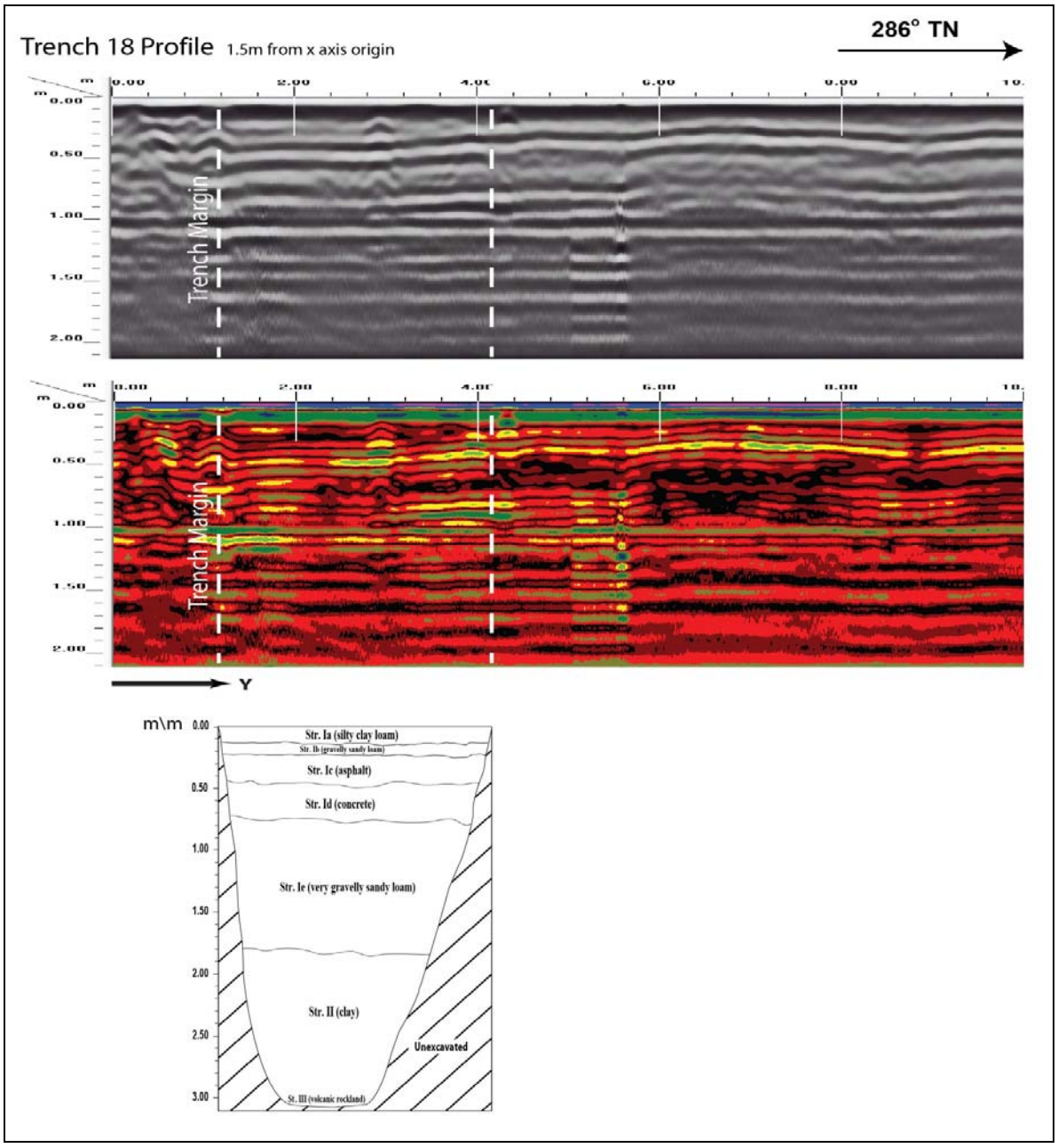

Figure 82. Visual comparison of excavated profile and GPR signal profile of Excavation 18

Excavation 19

Excavation 19 measured 0.9 meters by 3 meters and was oriented East to West and was located within a landscaped area South of Nimitz Highway and approximately 1 meter North of the sidewalk. Elliot Street was approximately 186 meters West and Aolele Street approximately 190 meters to the East of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: power line 2.5 meters to the West, drain line 9 meters to the South and a water line 9 meters to the South. No utilties transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 83).

GPR depth profiles for Excavation 19 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 84). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs and again around 100 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 125 cmbs.

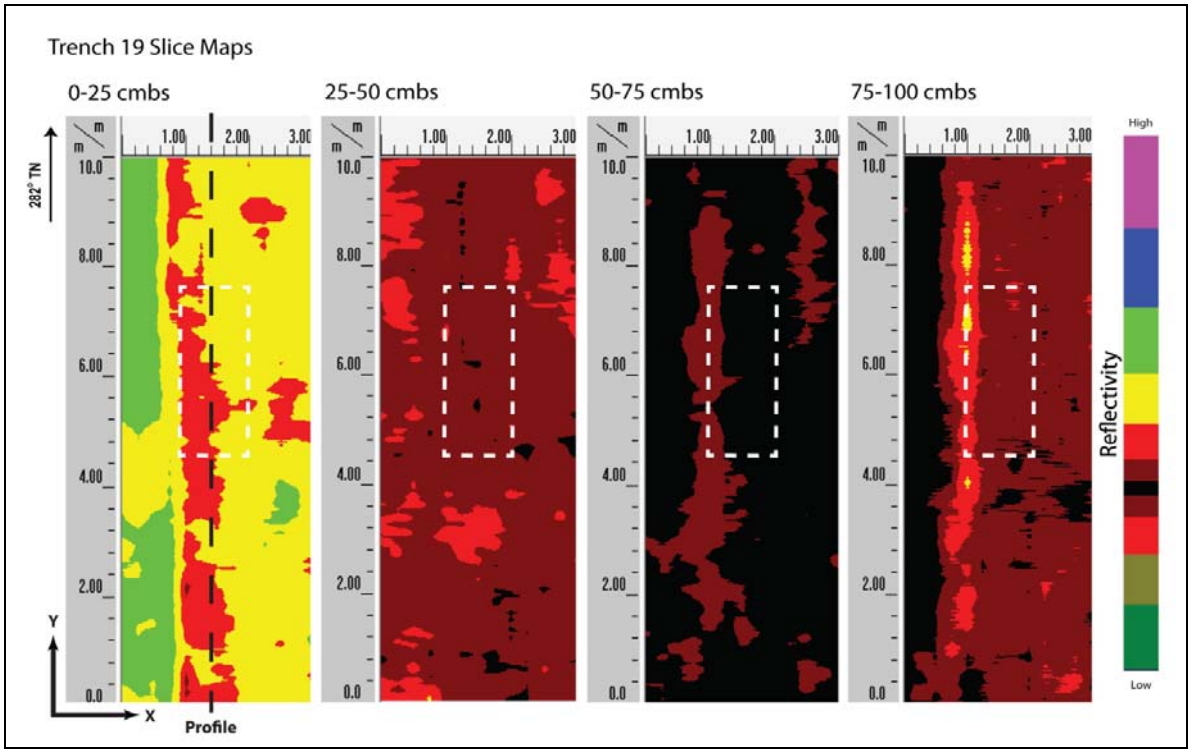

Figure 83. Slice maps of Excavation 19 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 84). Strata Ia and Ib are clearly observed and occur at the ground-truthed depths. An increase in reflectivity around 90 cmbs may represent stratum Id which is crushed asphalt. No discrete objects were observed in the GPR results.

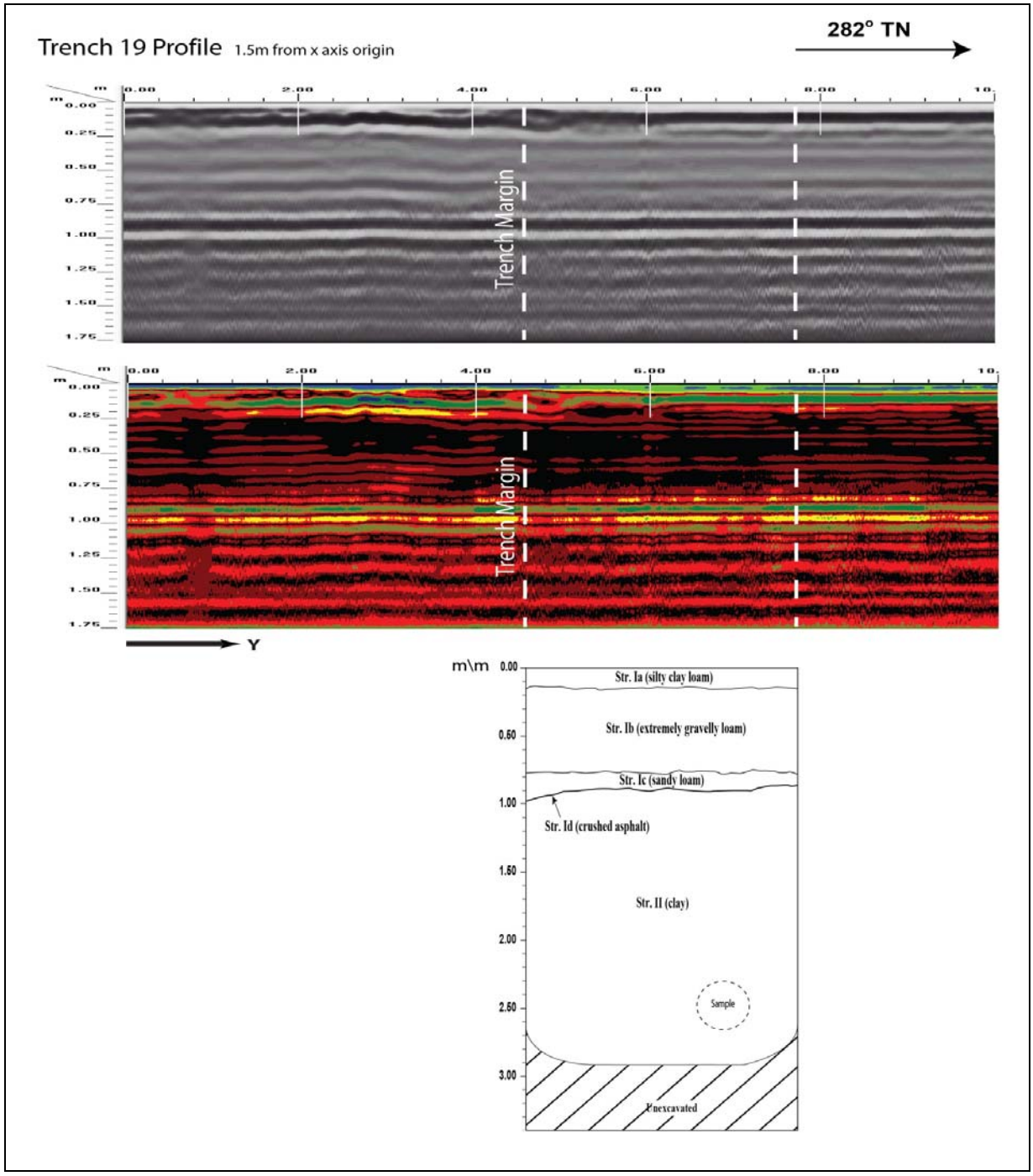

Figure 84. Visual comparison of excavated profile and GPR signal profile of Excavation 19

Excavation 20

Excavation 20 measured 0.9 meters by 3 meters and was oriented East to West and was located within a grassy median East of Aolele Street and West of the Post Office. Nimitz Highway was approximately 122 meters to the North of the excavation. The GPR grid measured 3 meters by 8 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: power line 8 meters to the East, water line 2 meters to the South and a drain 3 meters to the North. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 85).

GPR depth profiles for Excavation 20 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 86). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

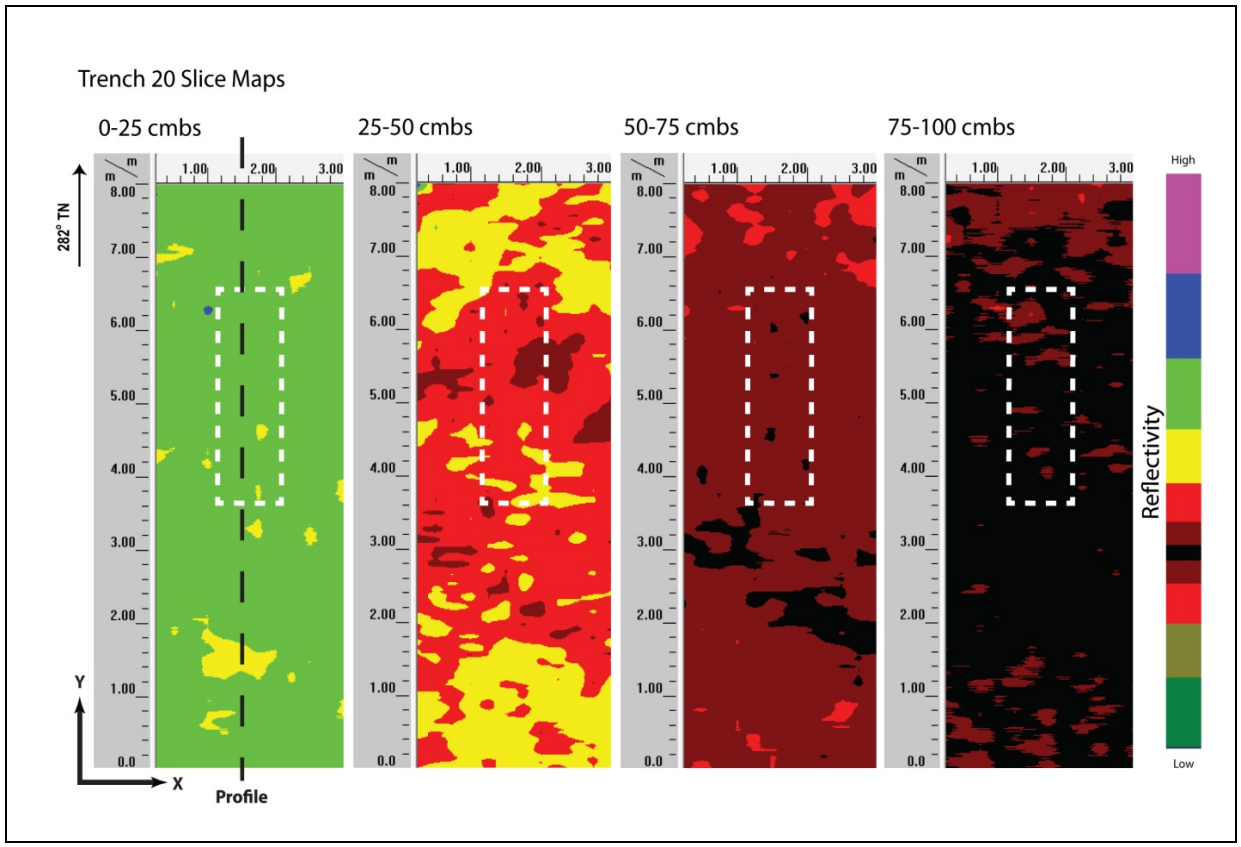

Figure 85. Slice maps of Excavation 20 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 86). Strata Ia to Ib are observed in the GPR profile and occur near the ground-truthed depths. A change in signal texture is noted at 90 cmbs and may represent the stratigraphic transition to stratum II. No discrete objects were observed in the GPR results.

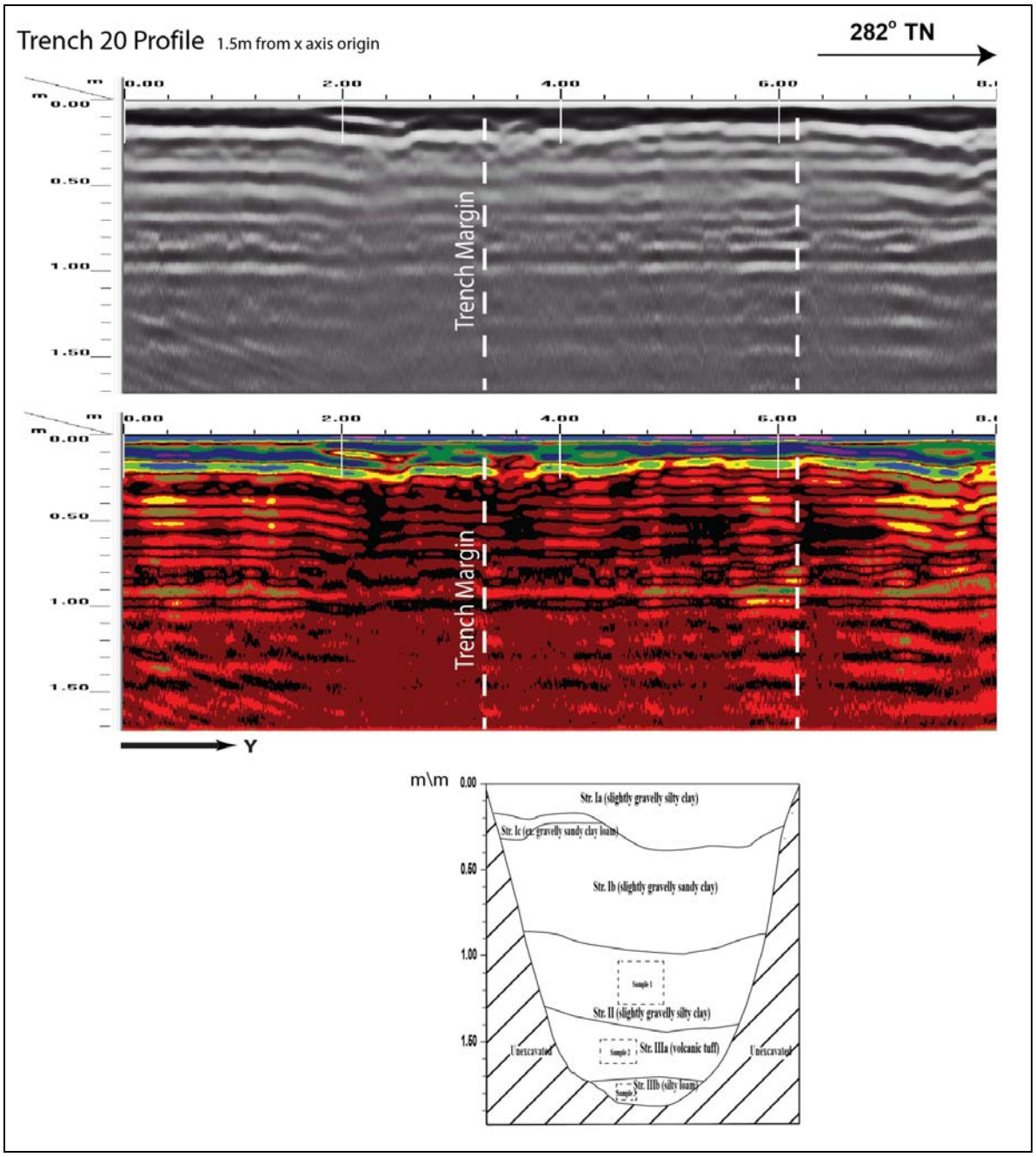

Figure 86. Visual comparison of excavated profile and GPR signal profile of Excavation 20

Excavation 21

Excavation 21 measured 0.9 meters by 3 meters and was oriented North to South and was located within a landscaped area 4 meters South of Ala Onaona Street. The Lei Stands were 18 meters South and Ala Auana Street is 82 meters East of the excavation. The GPR grid measured 3 meters by 8 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines 2 meters to the East and 8 meters to the North. An irrigation line was encountered at 25-30 cmbs near the center of the excavation.

A review of amplitude slice maps does not clearly indicate any linear features although a utility was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 87).

GPR depth profiles for Excavation 21 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 88). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 50 cmbs. No utilities were observed in the profile but a utility was encountered during excavation. The maximum depth of clean signal return was approximately 125 cmbs.

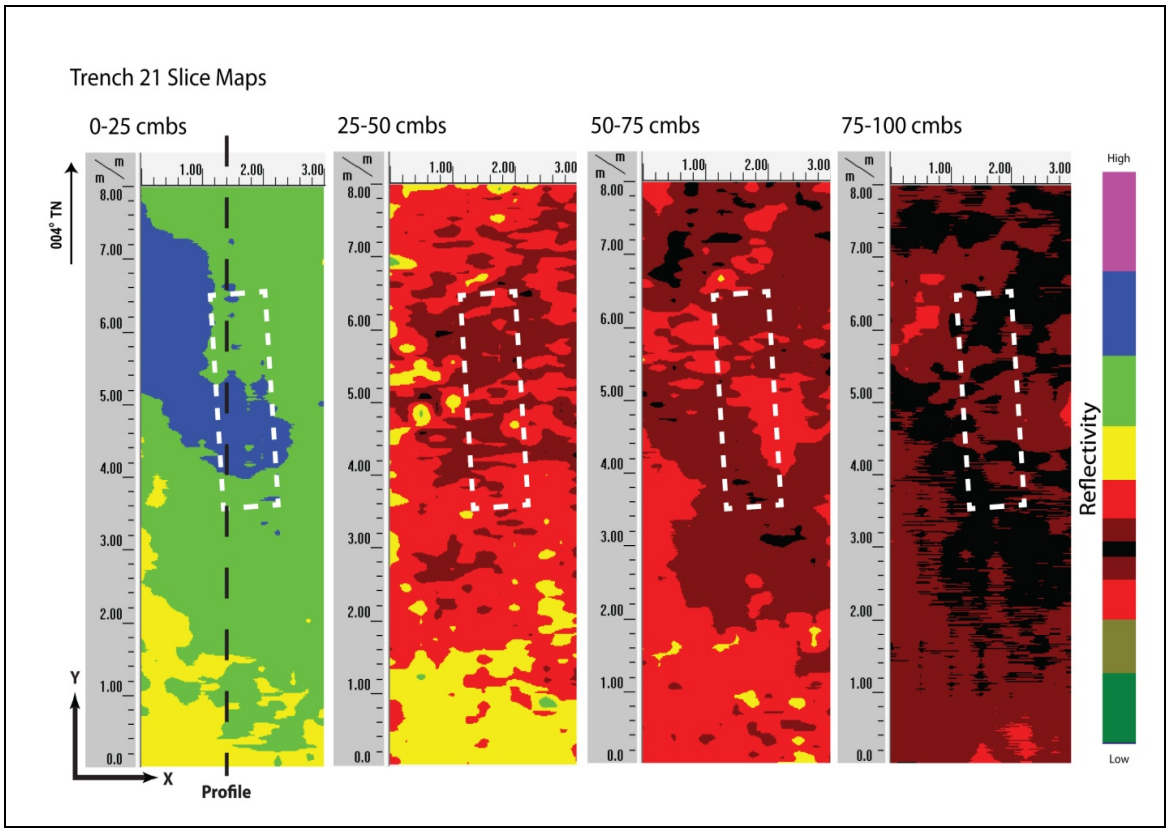

Figure 87. Slice maps of Excavation 21 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a weak correlation in stratigraphic transitions (Figure 88). The GPR results suggest a sediment transiton at ~25 cmbs which was not seen during excavation. The transition from stratum Ia to Ib is observed at 50 cmbs. An irrigation line was discovered during excavation but is not seen in the GPR results. No discrete objects or other stratigraphic transitions were observed in the GPR results.

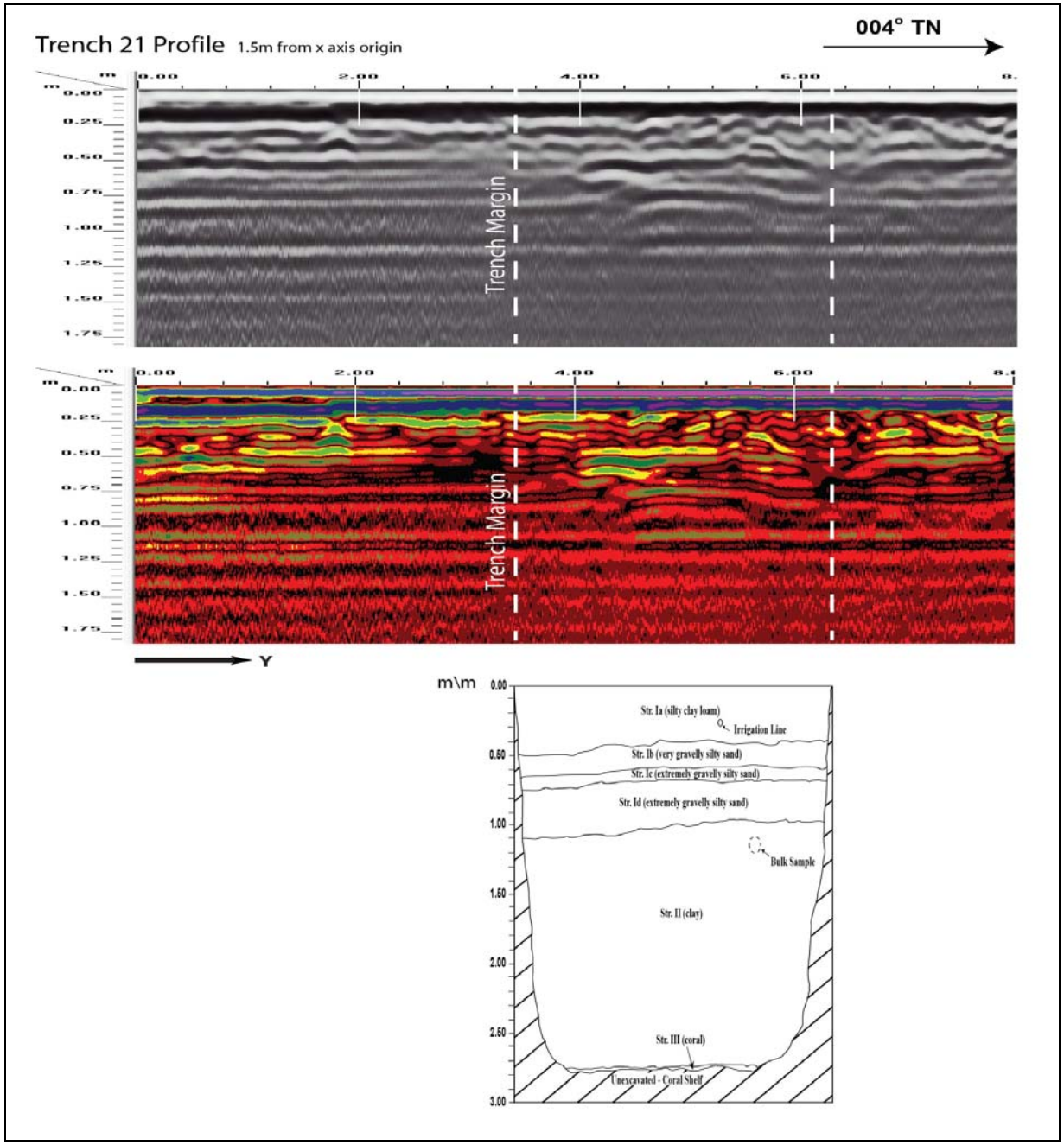

Figure 88. Visual comparison of excavated profile and GPR signal profile of Excavation 21

Excavation 22

Excavation 22 measured 0.6 by 6 meters and was oriented East to West and was located within the economy parking lot 6 meters South of Ala Onaona Street and approximately 38 meters East of Ala Auana Street. The Lei Stands were 55 meters to the Southwest of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain line 2 meters to the South, water line 2.5 meters to the Northeast. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 89).

GPR depth profiles for Excavation 22 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 90). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

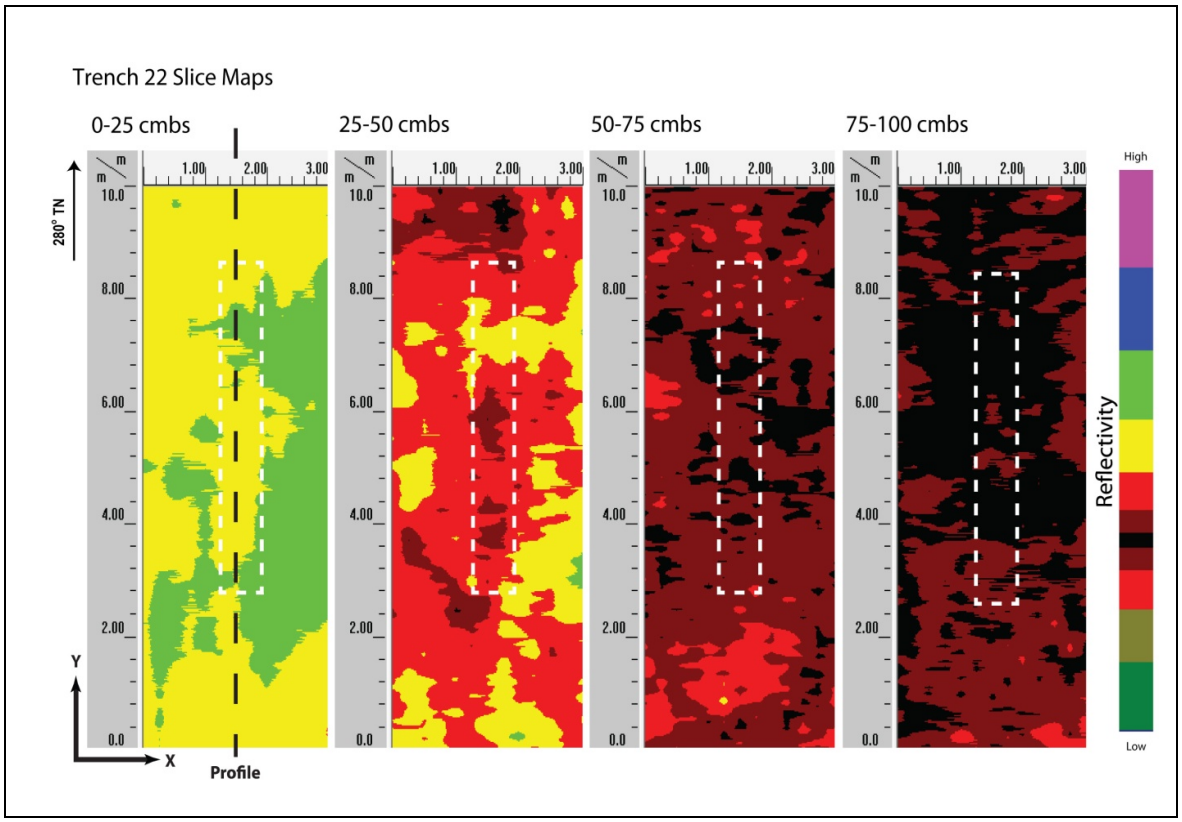

Figure 89. Slice maps of Excavation 22 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 90). Strata Ia and Ib are clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ic which was very gravelly sand. No discrete objects or other stratigraphic transitions were observed in the GPR results.

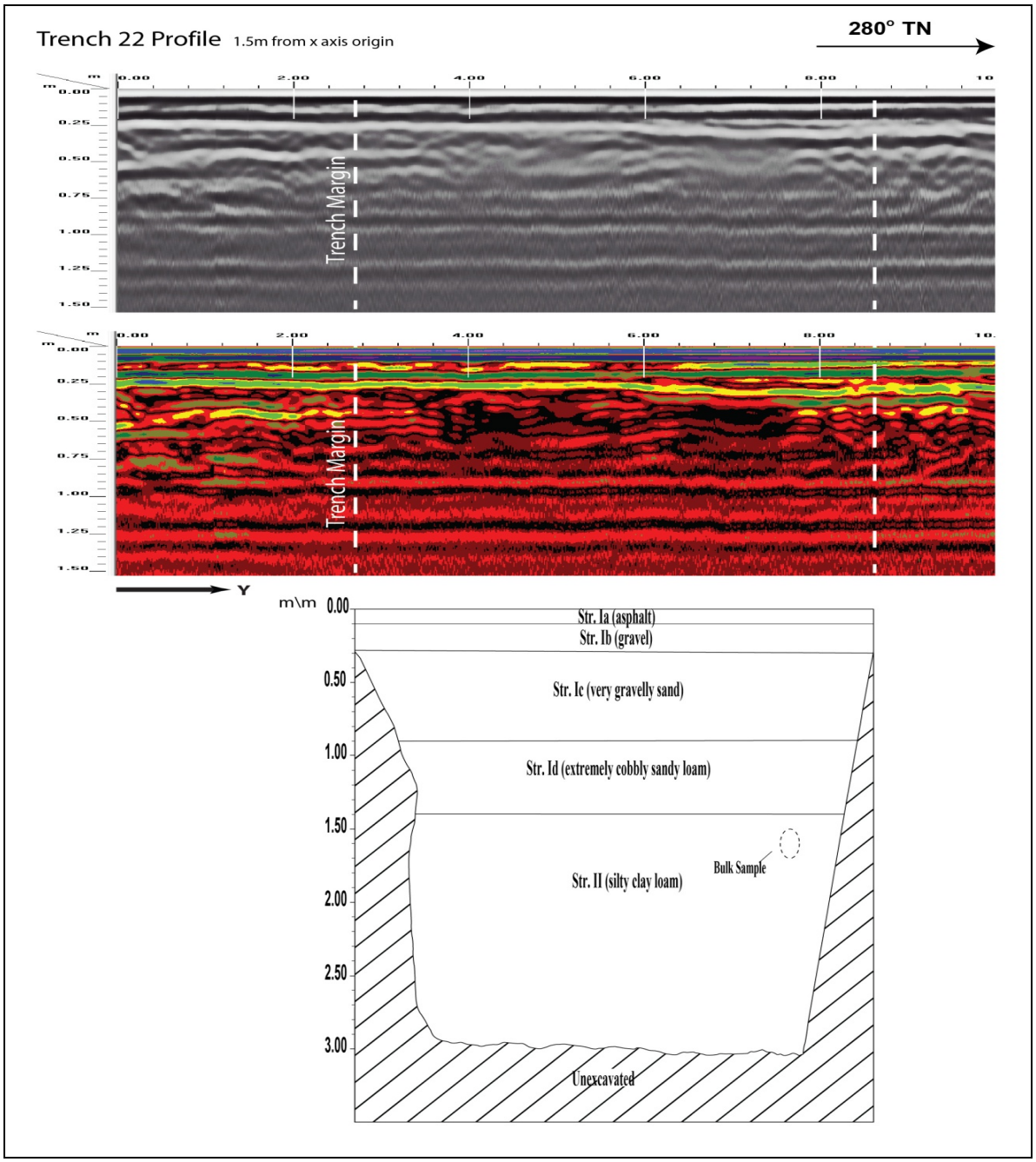

Figure 90. Visual comparison of excavated profile and GPR signal profile of Excavation 22

Excavation 23

Excavation 23 measured 0.6 by 6 meters and was oriented North to South and was located within the economy parking lot 19 meters South of Ala Onaona Street and approximately 34 meters East of Ala Auana Street. The Lei Stands were 49 meters to the West of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain line 9 meters to the North. A 3” PVC pipe was encountered 84 cmbs running East to West on the Northern end of the excavation.

A review of amplitude slice maps indicates a linear feature which corresponds to the utility pipe encountered during excavation . Reflectivity is realitively uniform throughout the grid and decreases with depth except where the utility was encountered. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs and increases again at 75 cmbs (Figure 91).

GPR depth profiles for Excavation 23 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 92). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 35 cmbs. A utility is clearly depicted in the profile with a large hyperbola corresponding to the location of the utility. The maximum depth of clean signal return was approximately 150 cmbs.

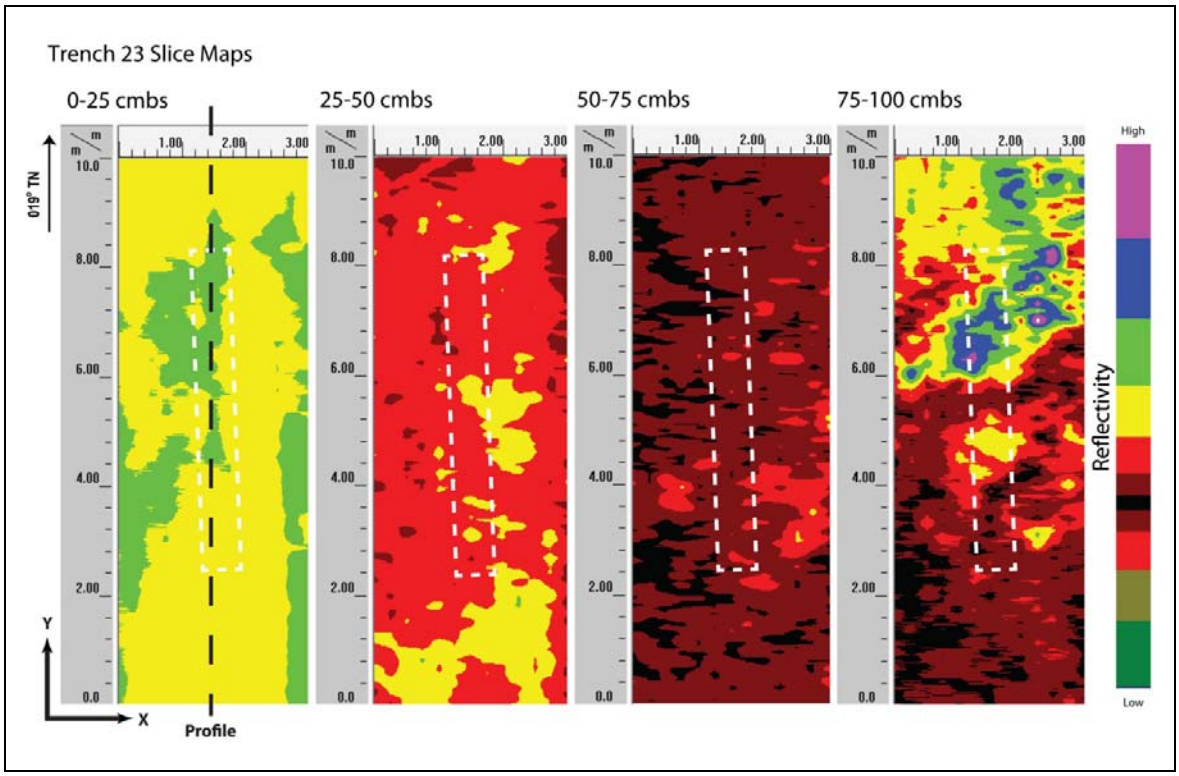

Figure 91. Slice maps of Excavation 23 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 92). Strata Ia to If are clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Id which was very gravelly to cobbly silt sand. During excavation a utility was found running perpendicular to the excavation and is seen as a hyperbola in the northern edge of the excavation at ~100 cmbs. No other discrete objects were observed in the GPR results.

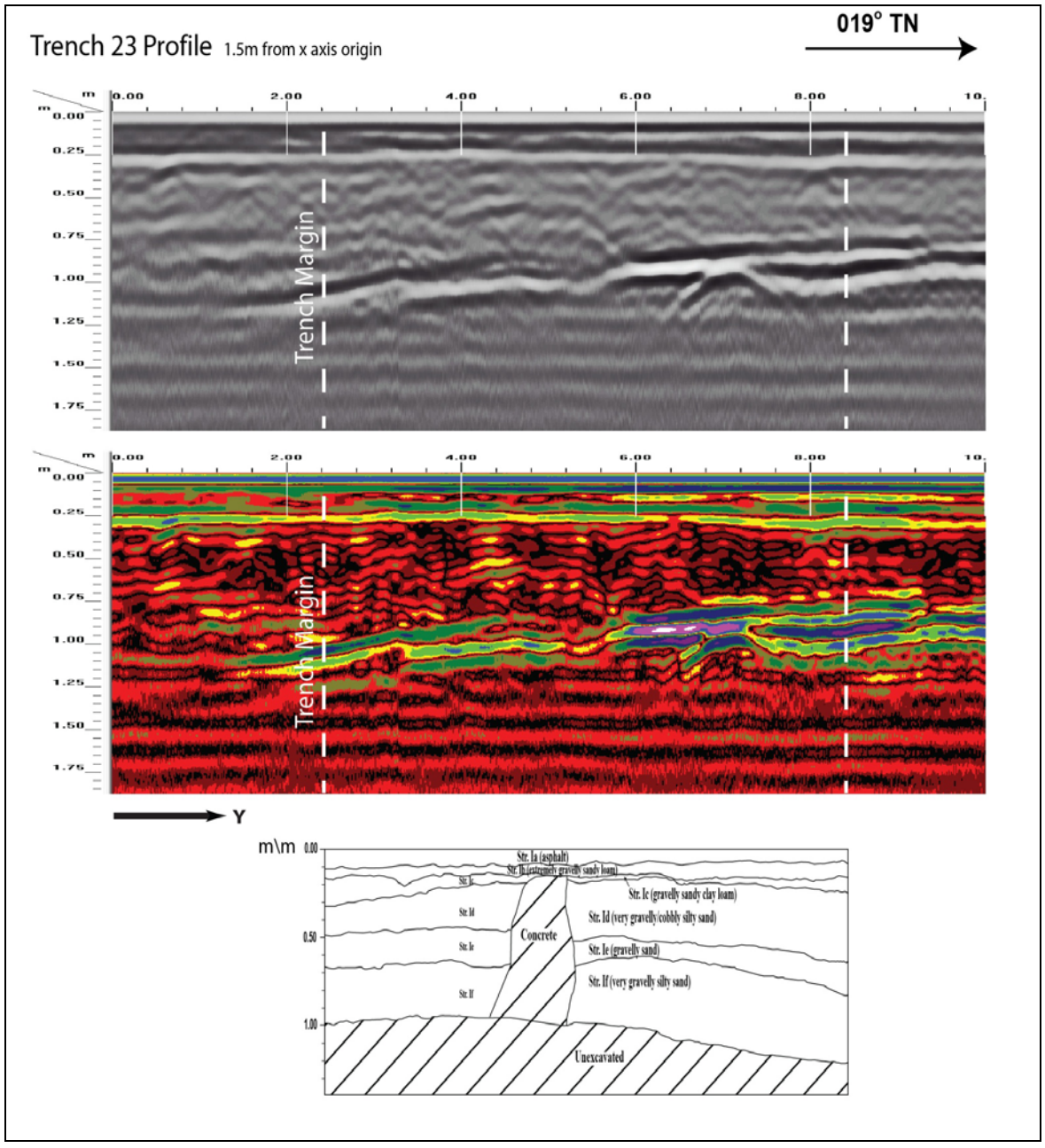

Figure 92. Visual comparison of excavated profile and GPR signal profile of Excavation 23

Excavation 24

Excavation 24 measured 0.6 by 6 meters and was oriented East to West and was located within the economy parking lot 19 meters South of Ala Onaona Street and approximately 45 meters East of Ala Auana Street. The Lei Stands were 60 meters to the West of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain line 11.5 meters to the North. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 93).

GPR depth profiles for Excavation 24 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 94). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

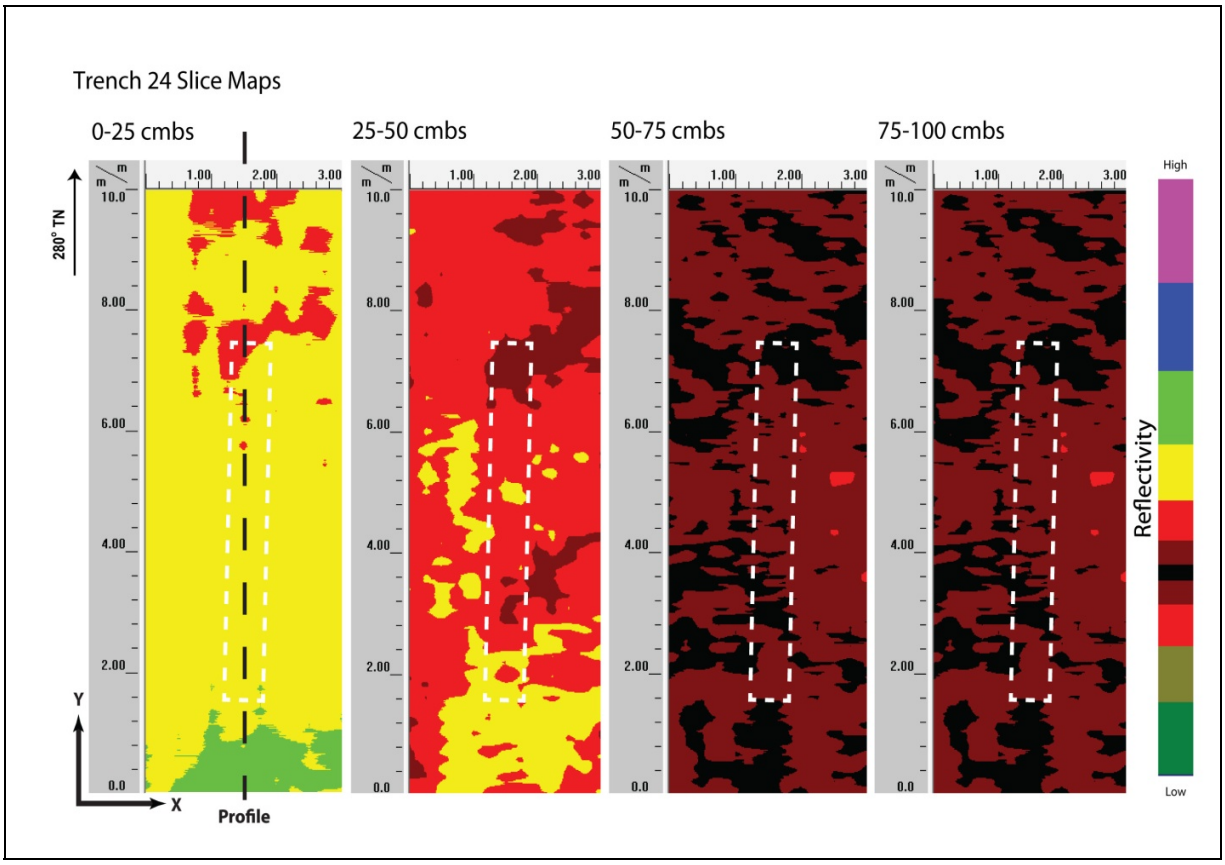

Figure 93. Slice maps of Excavation 24 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a weak correlation in stratigraphic transitions (Figure 94). The transitions of Strata Ia to Ic are not clearly shown in the GPR profile at the ground-truthed depths. A concrete slab was found at 108 cmbs during excavation which was not seen in the GPR profile. No other discrete objects were observed in the GPR results or subsequent excavation.

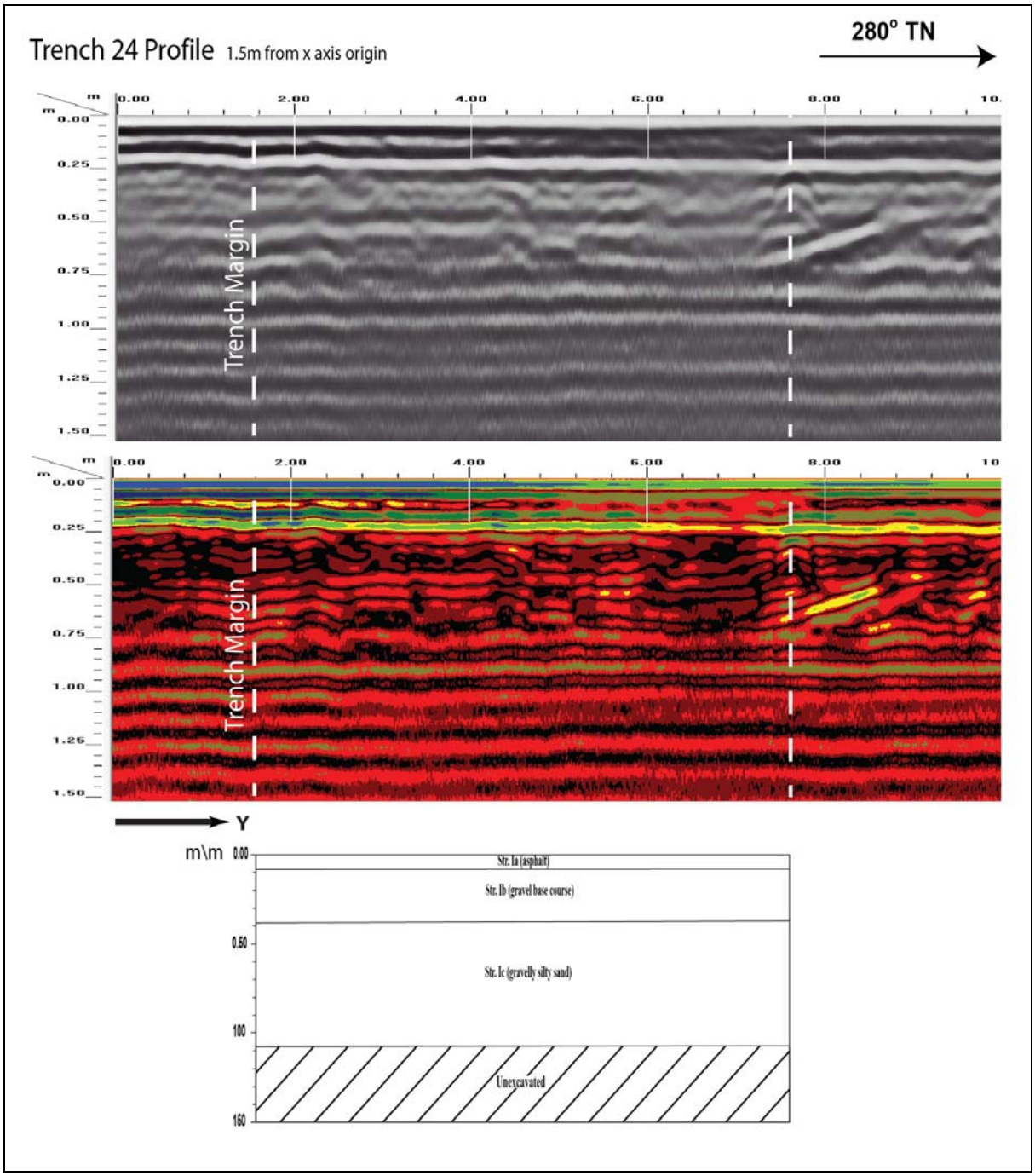

Figure 94. Visual comparison of excavated profile and GPR signal profile of Excavation 24

Excavation 25

Excavation 25 measured 0.6 by 6 meters and was oriented East to West and was located within the economy parking lot 9 meters South of Ala Onaona Street and approximately 59 meters East of Ala Auana Street. The Lei Stands were 74.5 meters to the West of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain lines 10 meters to the East and 3.5 meters to the North. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 75 cmbs (Figure 95).

GPR depth profiles for Excavation 25 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 96). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 75 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 125 cmbs.

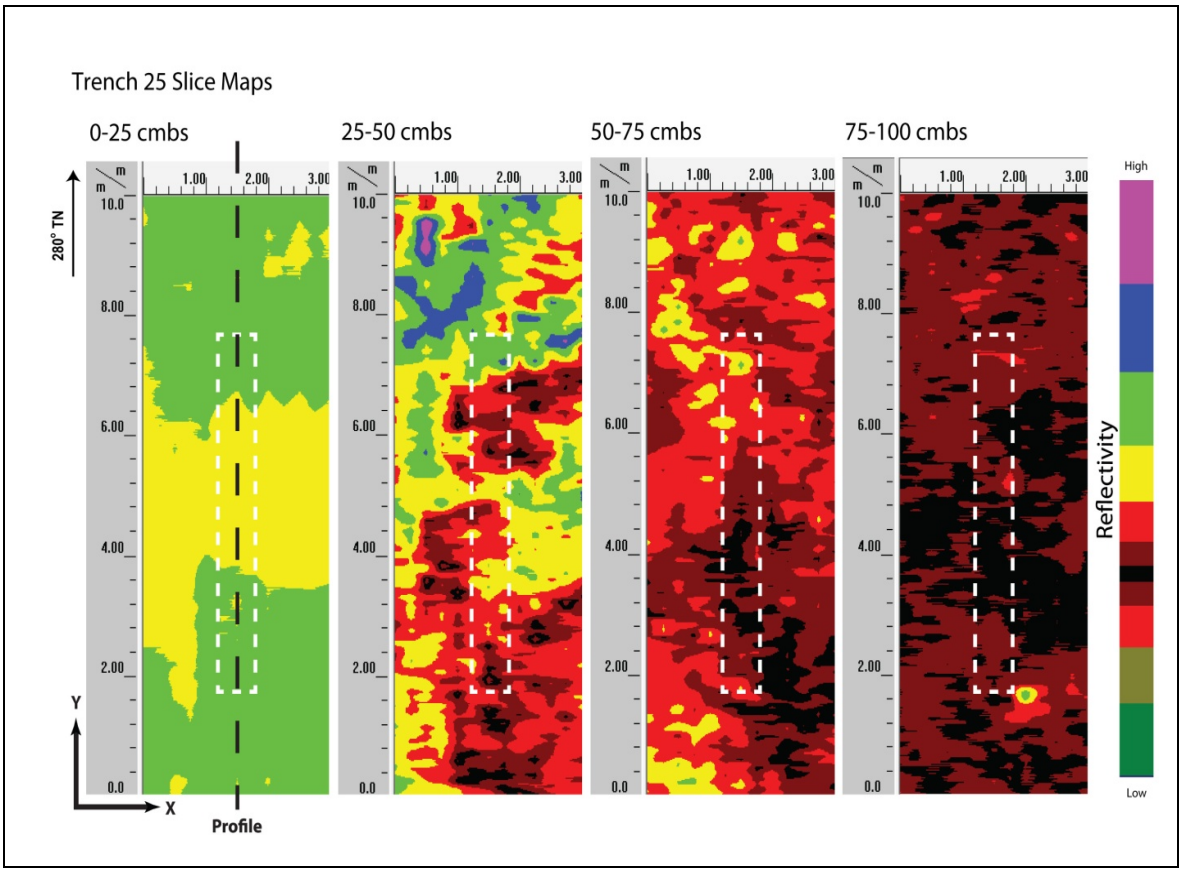

Figure 95. Slice maps of Excavation 25 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 96). Strata Ia to Ic are clearly shown in the GPR profile. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ic which was determined to be crushed coral. A concrete slab was found at 90 cmbs during excavation which was not seen in the GPR profile. No discrete objects were observed in the GPR results or subsequent excavation.

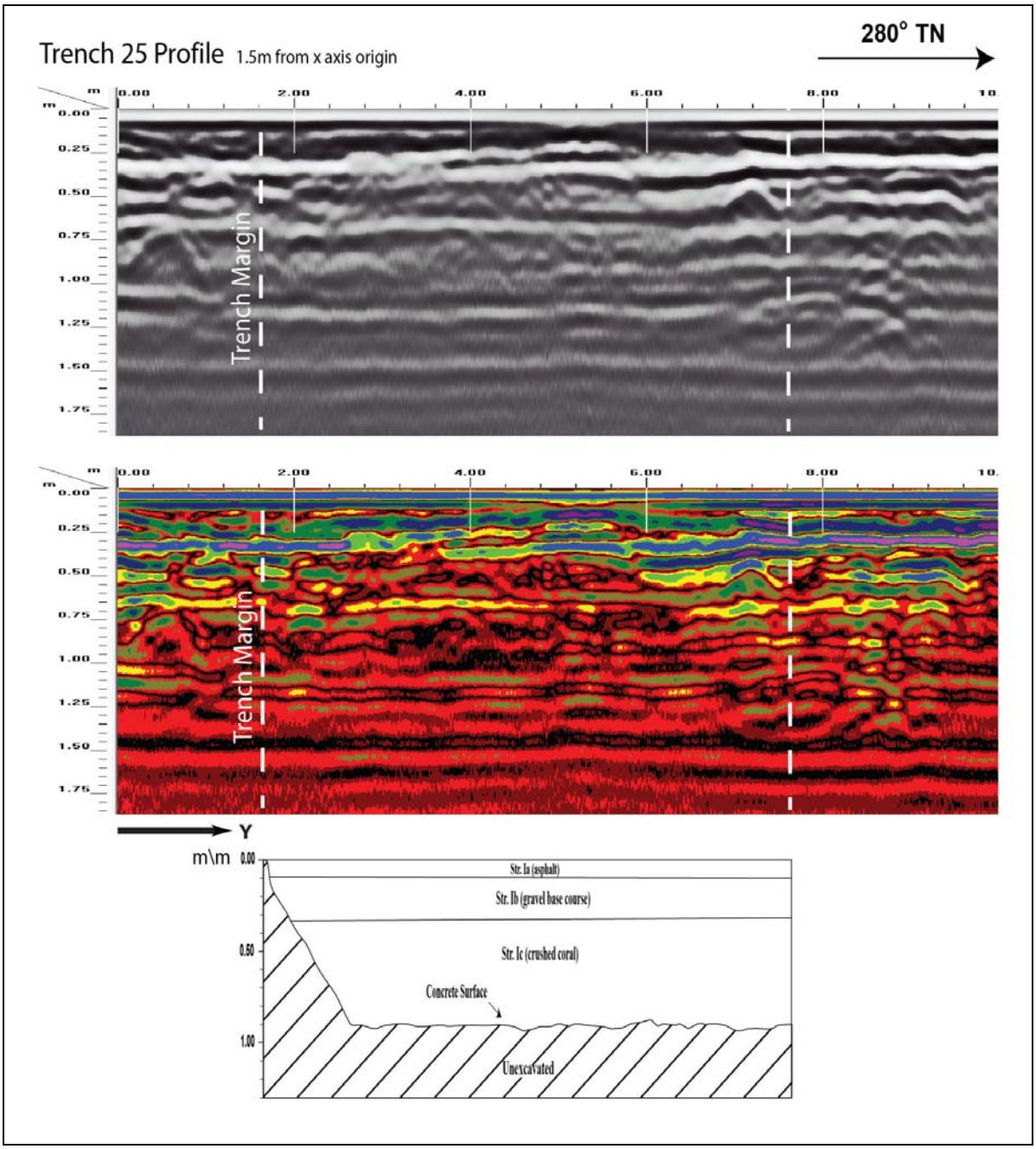

Figure 96. Visual comparison of excavated profile and GPR signal profile of Excavation 25

Excavation 26

Excavation 26 measured 0.6 by 6 meters and was oriented North to South and was located within the economy parking lot 14 meters South of Ala Onaona Street and approximately 80 meters East of Ala Auana Street. The Lei Stands were 94 meters to the West of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain lines 10 meters to the West and 6 meters to the Southeast, gas line 20 meters to the East. No utilties transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 97).

GPR depth profiles for Excavation 26 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 98). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs and again around 75 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

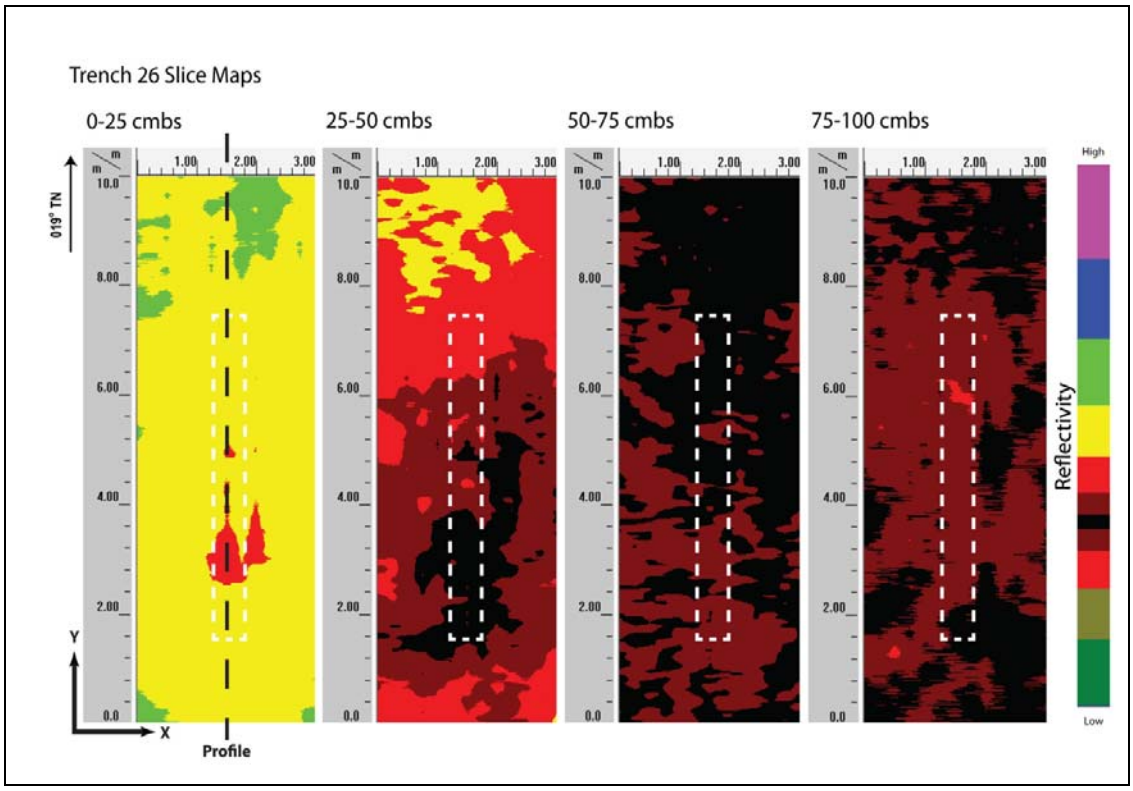

Figure 97. Slice maps of Trench 26 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 98). Strata Ia to Ic are clearly shown in the GPR profile but occur slightly deeper when ground-truthed, which may be attributed to an incorrect dielectric value. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ic which was determined to be crushed coral. A concrete slab was found at 90 cmbs during excavation which was not seen in the GPR profile. No discrete objects were observed in the GPR results or subsequent excavation.

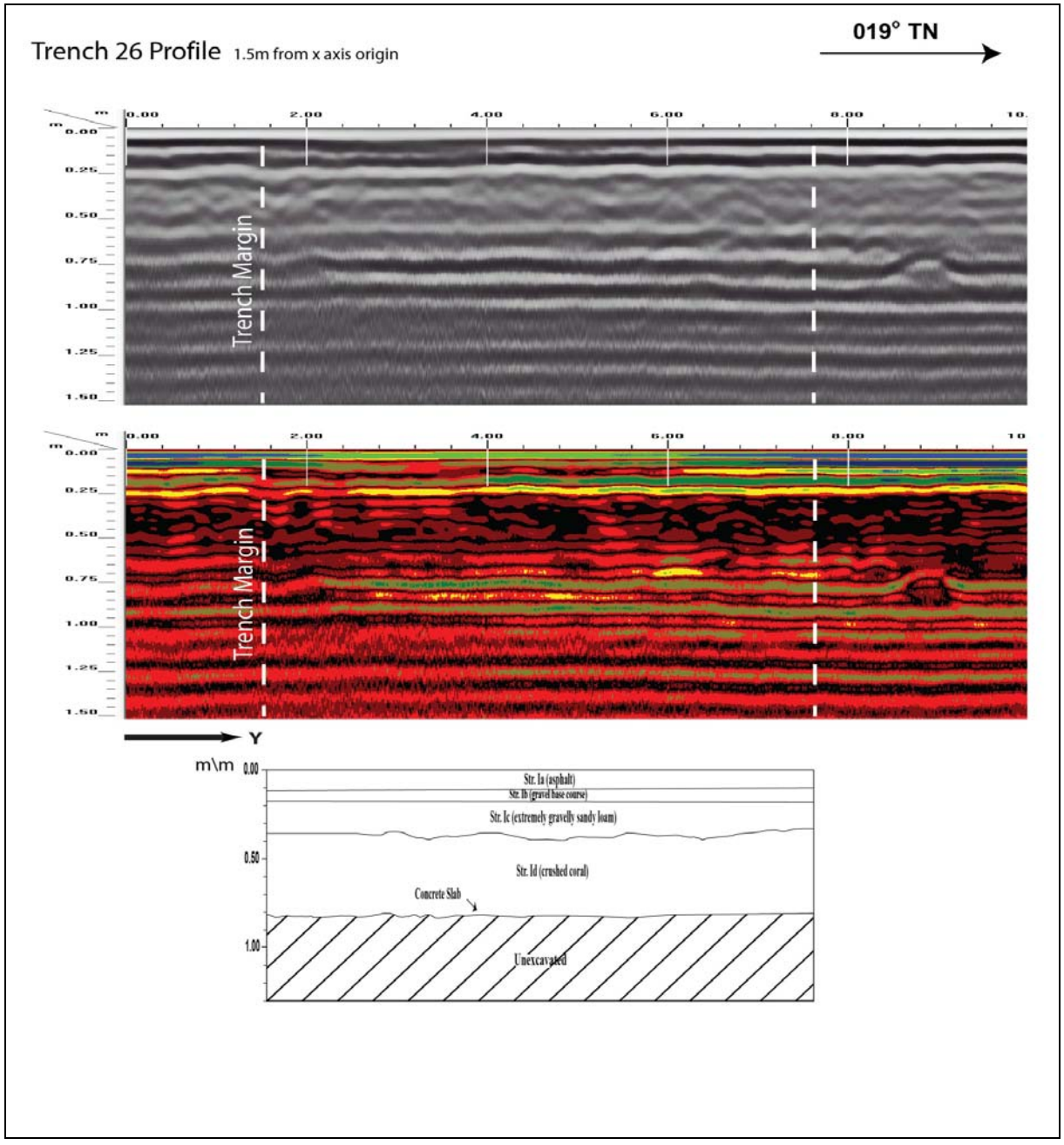

Figure 98. Visual comparison of excavated profile and GPR signal profile of Excavation 26

Excavation 27

Excavation 27 measured 0.9 by 3 meters and was oriented East to West and was located within a landscaped median between Ala Onaona Street and Airport Parking Lot 3 .The Paiea Street and Aolele Street mergewas 35 meters to the Northeast. The GPR grid measured 1.5 meters by 4 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines 4.5 meters to the South and 7.5 meters to the North and a communication line 4.5 meters to the North. An irrigation line was encountered at 45 cmbs along the South wall of the excavation.

A review of amplitude slice maps may not clearly indicate any linear features although a utility was encountered during excavated. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 99).

GPR depth profiles for Excavation 27 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 100). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 20 cmbs and again around 60 cmbs. No utilities were observed in the profile although a utility was encountered during excavation. The maximum depth of clean signal return was approximately 75 cmbs.

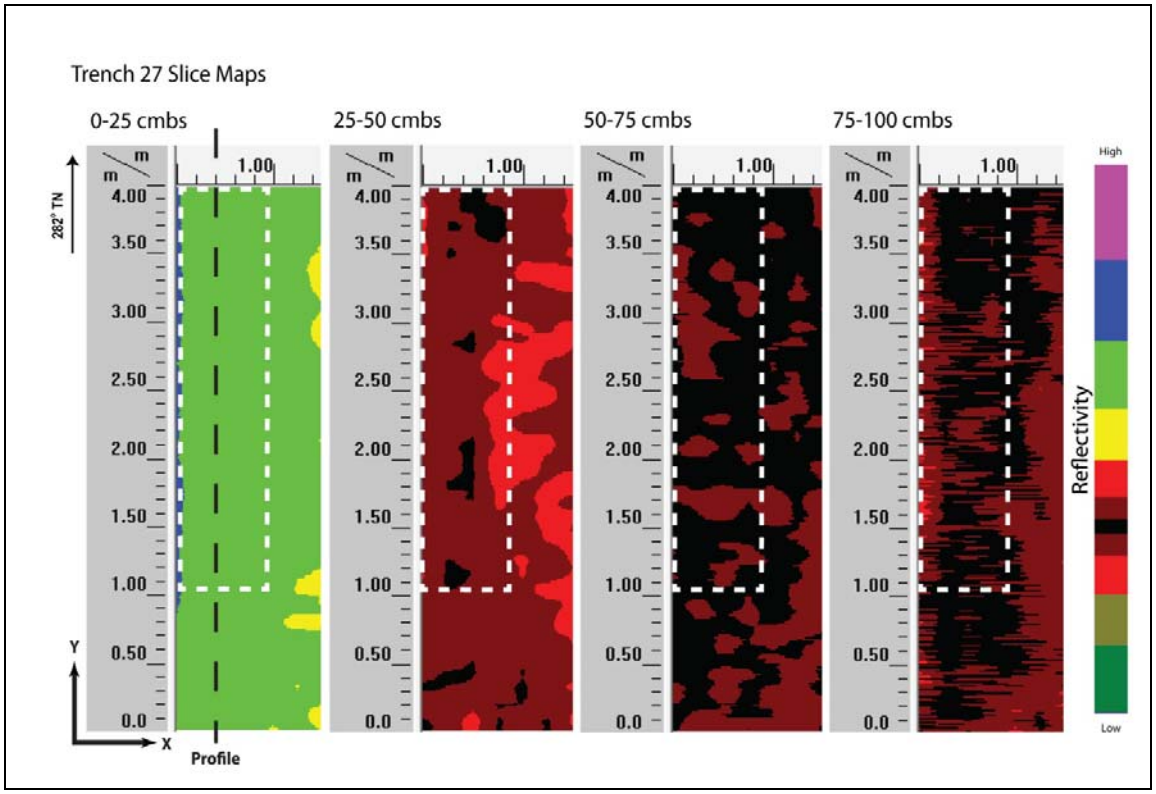

Figure 99. Slice maps of Excavation 27 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 100). Strata Ia to Ib are clearly shown in the GPR profile. Stratum Ic was a layer of asphalt and may be represented by a horizontal band of higer reflectivity occuring at ~65 cmbs. No discrete objects were observed in the GPR results or subsequent excavation.

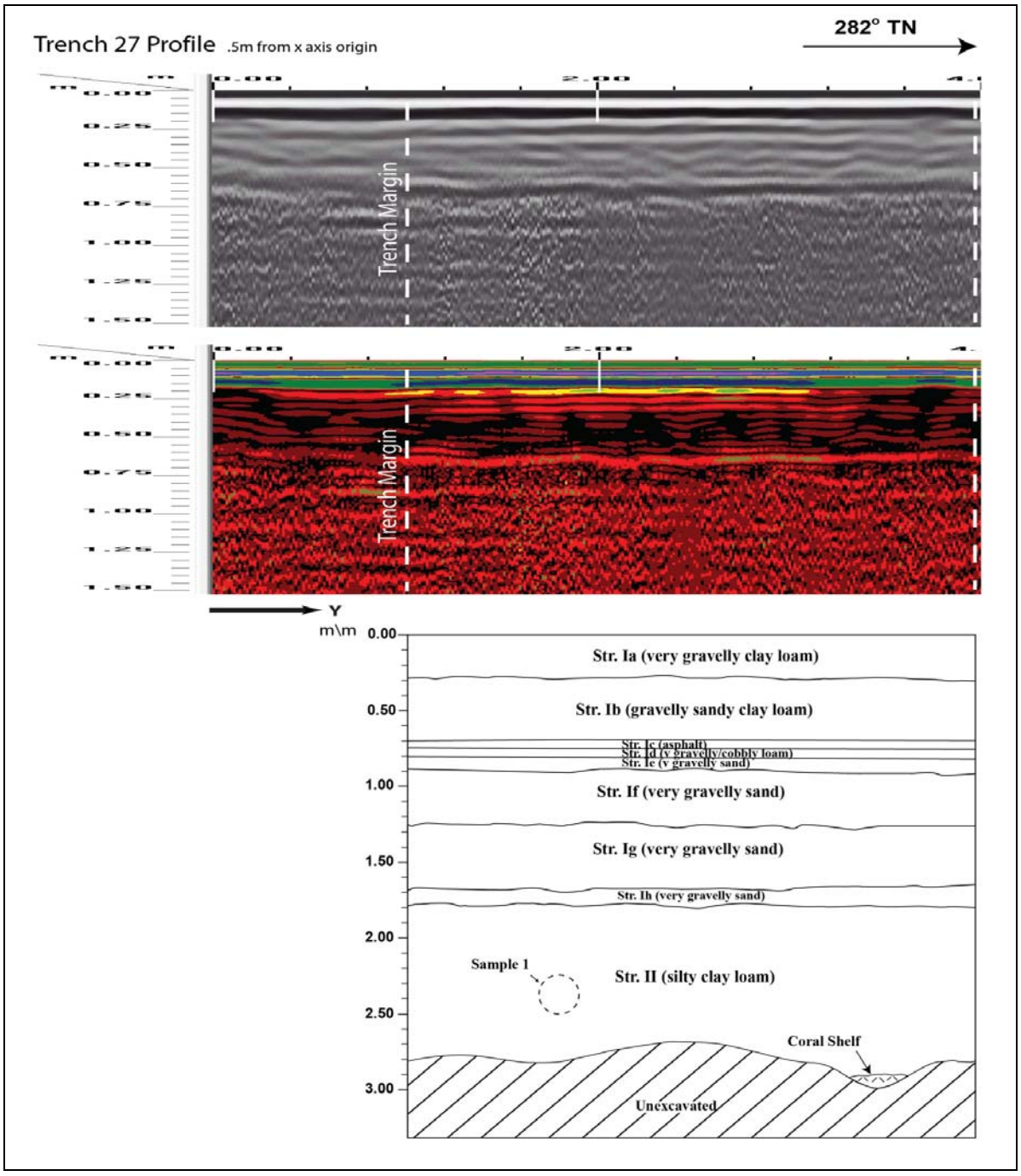

Figure 100. Visual comparison of excavated profile and GPR signal profile of Excavation 27

Excavation 28

Excavation 28 measured 0.9 by 3 meters and was oriented East to West and was located within a landscaped median between Aolele Street and the H1 Freeway on ramp. Aopoko Place was 27 meters Southeast, Aolewa Place was 97 meters West and Hawaii Fueling Facilities was 15 meters South of the excavation. The GPR grid measured 2 meters by 7 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include:water lines 2 meters to the North and 1.5 meters to the South, drain 1 meter to the East and fuel lines 3 meters to the South and 4 meters to the North. A dead metal pipe was encountered at 91 cmbs on the West end of the excavation.

A review of amplitude slice maps does not clearly indicate any linear features although a utility was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth except for the storm drain adjacent to the trench. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs and increases again around 75 cmbs (Figure 101).

GPR depth profiles for Excavation 28 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 102). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile although one was encountered during excavation and a storm drain is present on the East side of the grid. The maximum depth of clean signal return was approximately 150 cmbs.

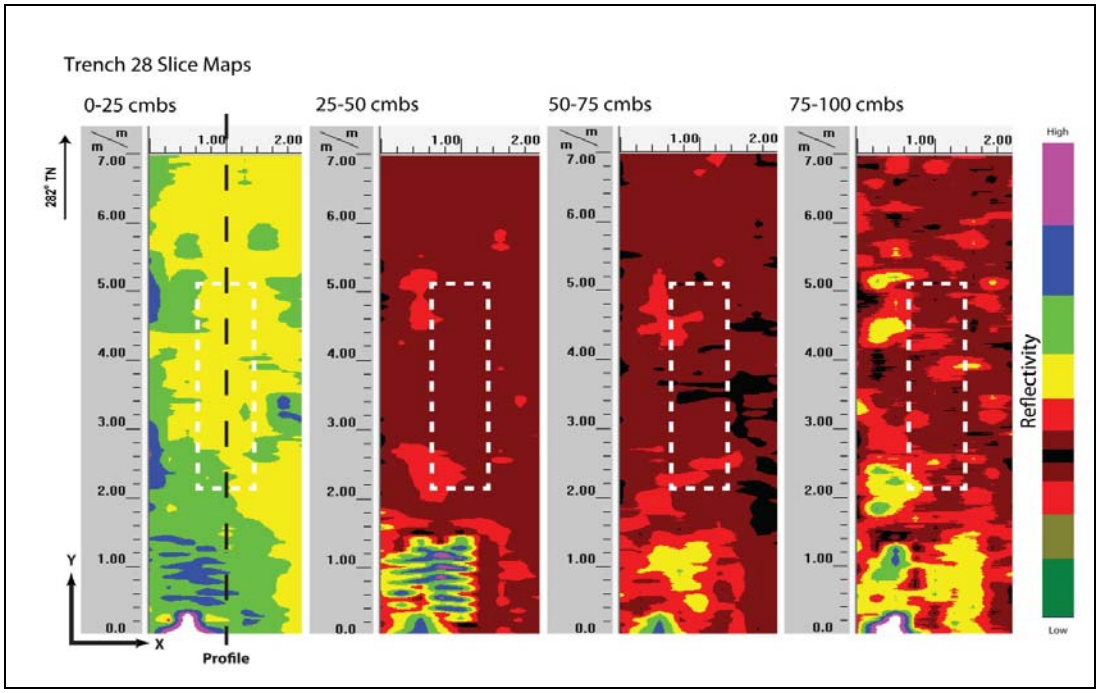

Figure 101. Slice maps of Excavation 28 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 102). Strata Ia to Ic are clearly shown in the GPR profile. Stratum Id occures at ~90 cmbs and may be represented by higher reflectivity with smooth banding. A utility was located within this stratum but did not show up on the GPR profile. All other sediment transitions are below the range of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

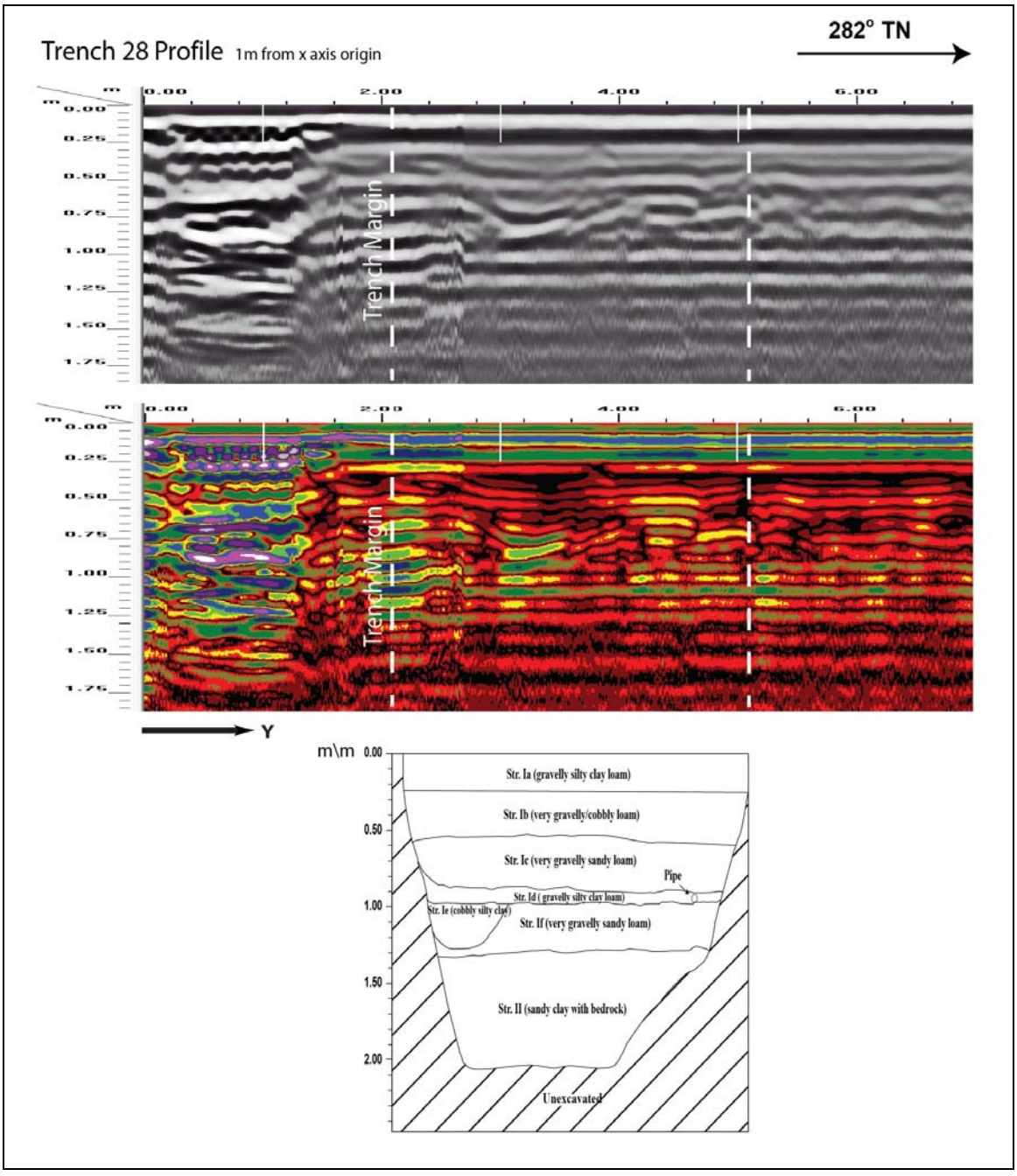

Figure 102. Visual comparison of excavated profile and GPR signal profile of Excavation 28

Excavation 29

Excavation 29 measured 0.9 by 3 meters and was oriented East to West and was located within the parking lot of Enterprise Rent-A-Car 8 meters South of Aolele Street. Aolewa Place was 37 meters to the East of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: gas line 2 meters to the North and a communication line 5 meters to the North. No utilties transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 103).

GPR depth profiles for Excavation 29 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 104). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 20 cmbs and again around 80 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 130 cmbs

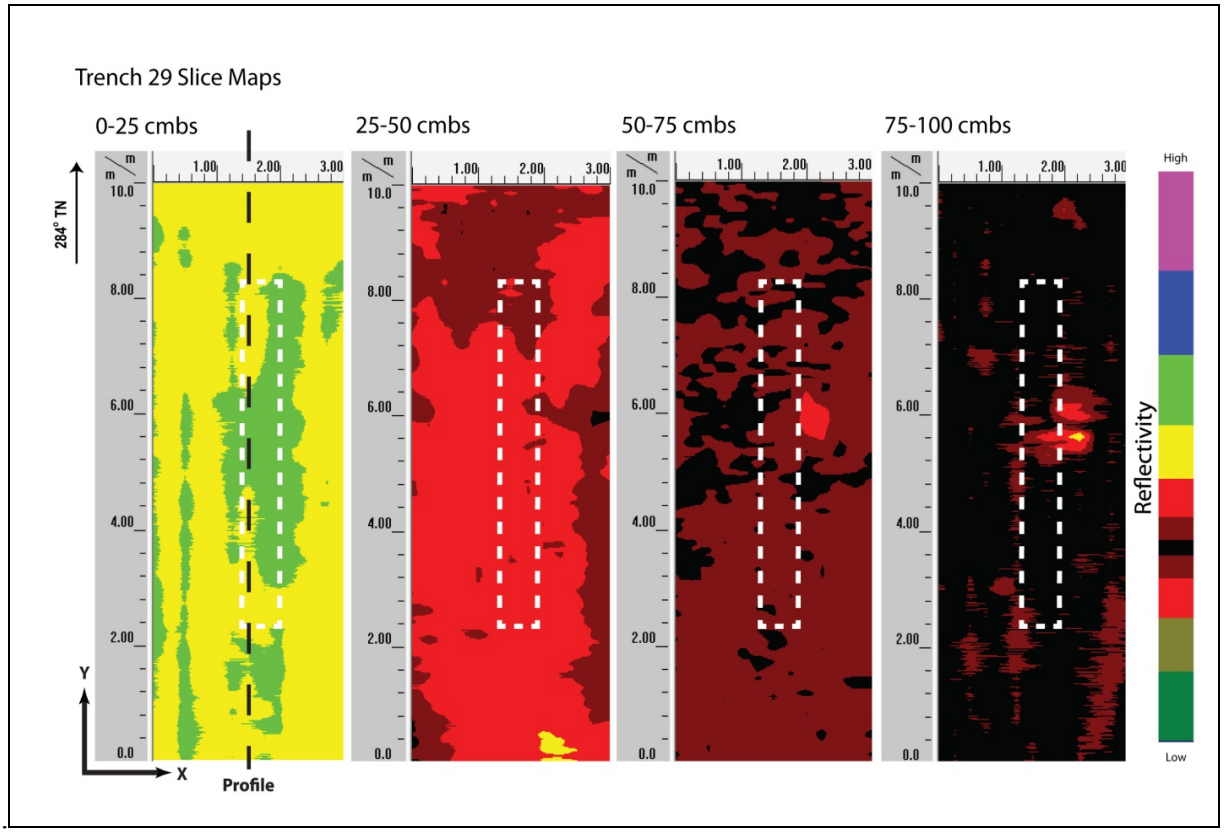

Figure 103. Slice maps of Excavation 29 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 104). Strata Ia and Ib are clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ib which represents very gravelly loam. All other sediment transitions are below the range of clean signal return. No discrete objects were observed in the GPR results.

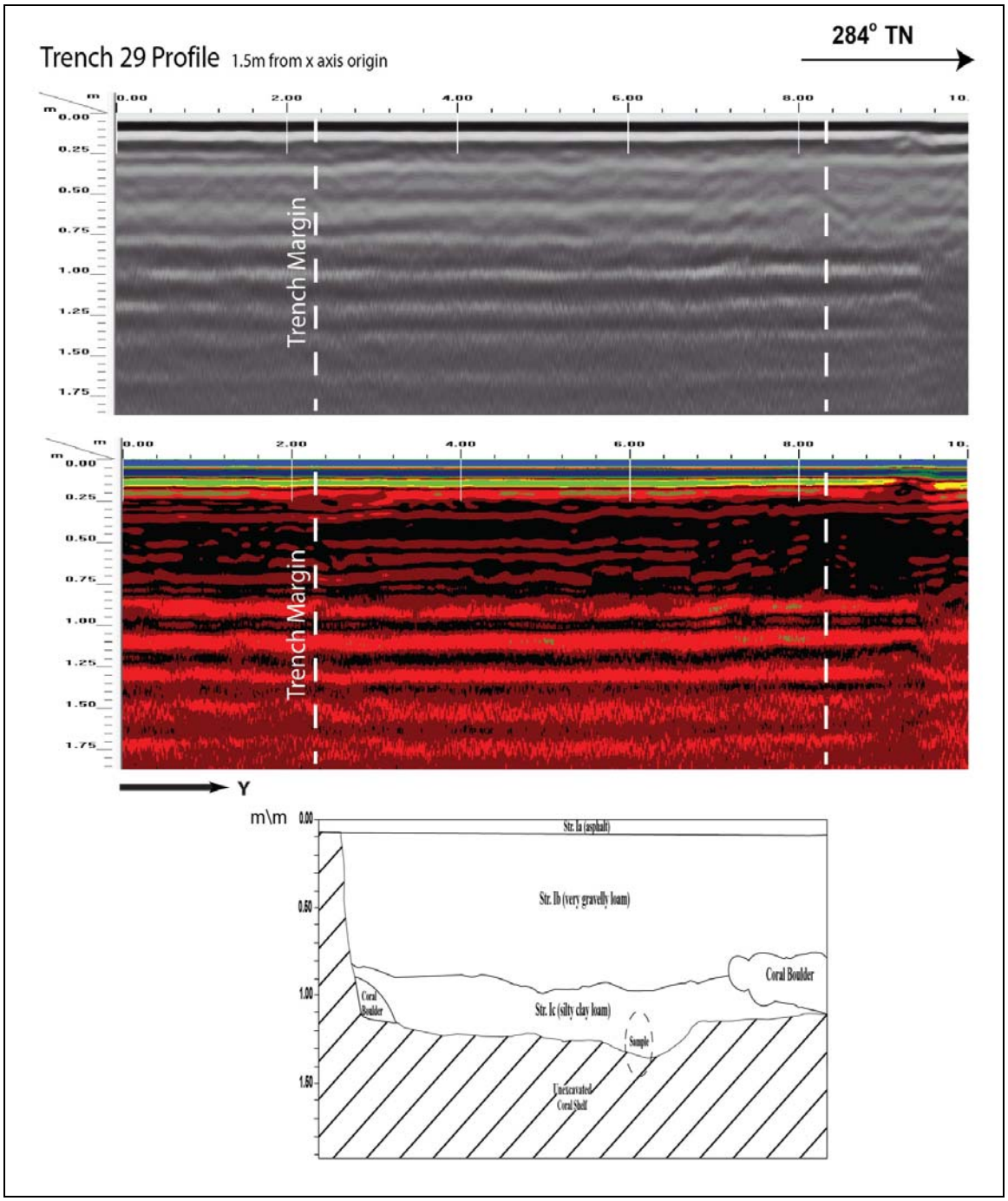

Figure 104. Visual comparison of excavated profile and GPR signal profile of Excavation 29

Excavation 30

Excavation 30 measured 0.9 by 3 meters and was oriented East to West and was located within a grassy field 13 meters North of Aolele Street 70 meters South of Ualena Street. Approved Forwarders of Hawaii was 40 meters Northwest and a drainage canal was 30 meters Southwest of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines 2 meters to the East, 4 meters to the South and 3 meters to the North. A PVC pipe was encountered 43 cmbs running North to South on the Western end of the excavation.

A review of amplitude slice maps indicates a linear feature around 25-50 cmbs which corresponds to a utility that was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth except for the area that contained the utility. A transition from higher reflectivity to lower reflectivity is observed at approximately 75 cmbs (Figure 105).

GPR depth profiles for Excavation 30 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 106). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. An anomaly was observed in the profile and corresponds to the utility encountered during excavation. The maximum depth of clean signal return was approximately 125 cmbs.

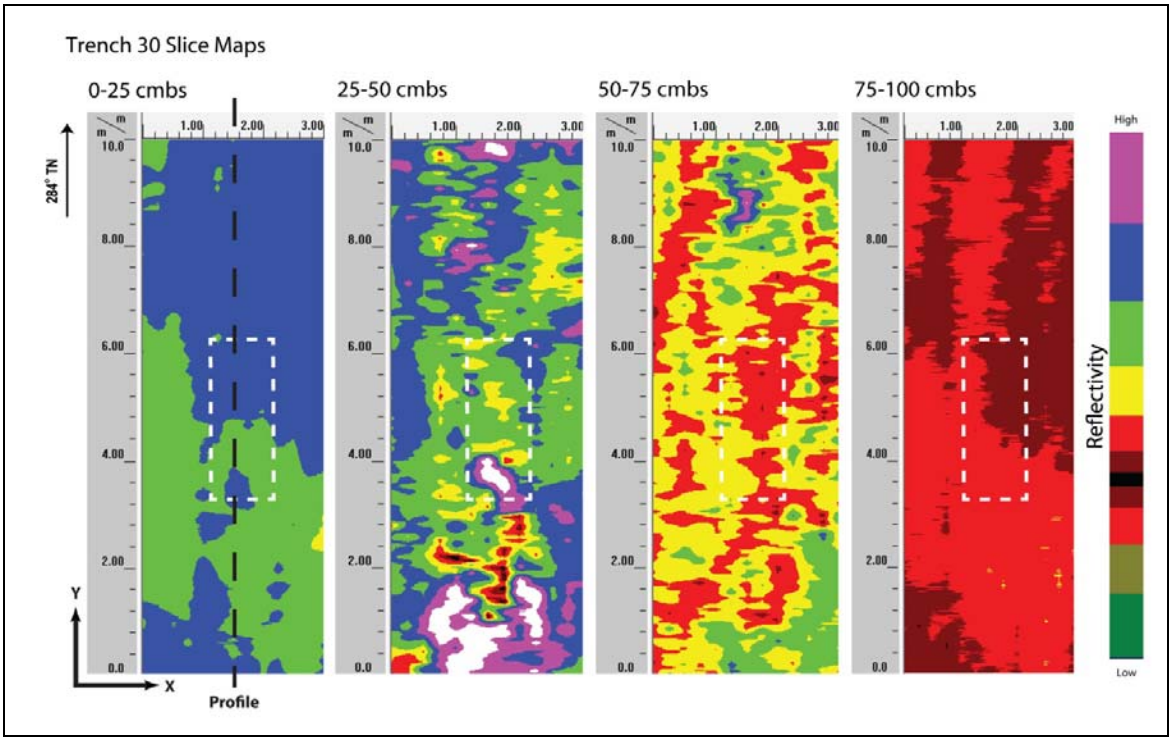

Figure 105. Slice maps of Excavation 30 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 106). Strata Ia through Ic are all clearly observed and occur at the ground-truthed depths. A PVC pipe located in Western edge of the excavation is clearly shown in the profile. All other sediment transitions are below the maxium depth of clean signal return. No other discrete objects were observed in the GPR results or subsequent excavation.

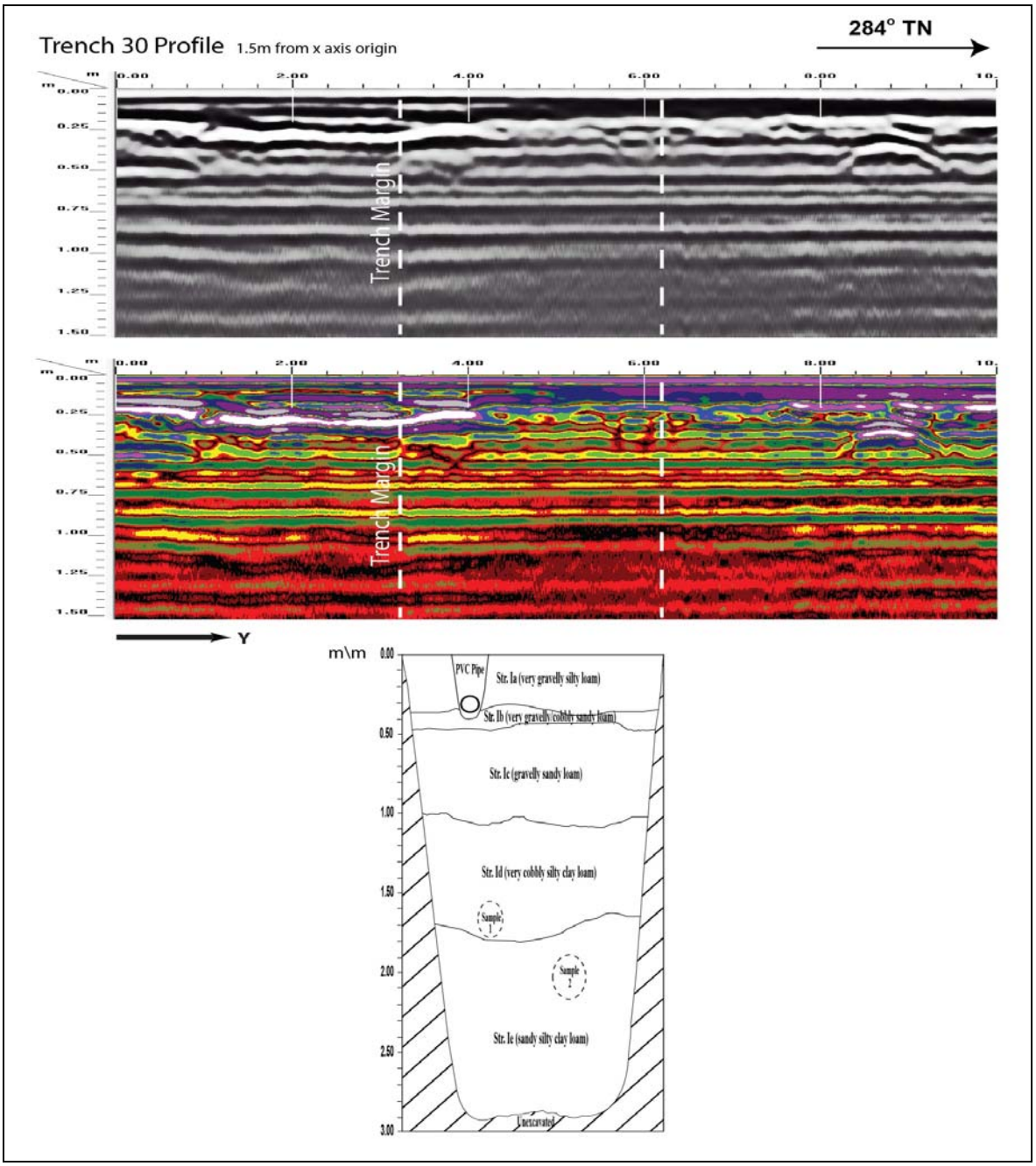

Figure 106. Visual comparison of excavated profile and GPR signal profile of Excavation 30

Excavation 31

Excavation 31 measured 0.9 meters by 3 meters and was oriented North to South and was located within a parking lot on Ualena Street. Savage Wholesale Building Materials was 25 meters North and Aloha State Sales was 13 meters Southeast of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: sewer line 3 meters to the East and water line 6 meters to the North. A dead utility line was encountered 50 cmbs and 80 cm from the North end of the excavation.

A review of amplitude slice maps does not clearly indicate any linear features although a utility was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 107).

GPR depth profiles for Excavation 31 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 108). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile but a utility was encountered during excavation. The maximum depth of clean signal return was approximately 125 cmbs.

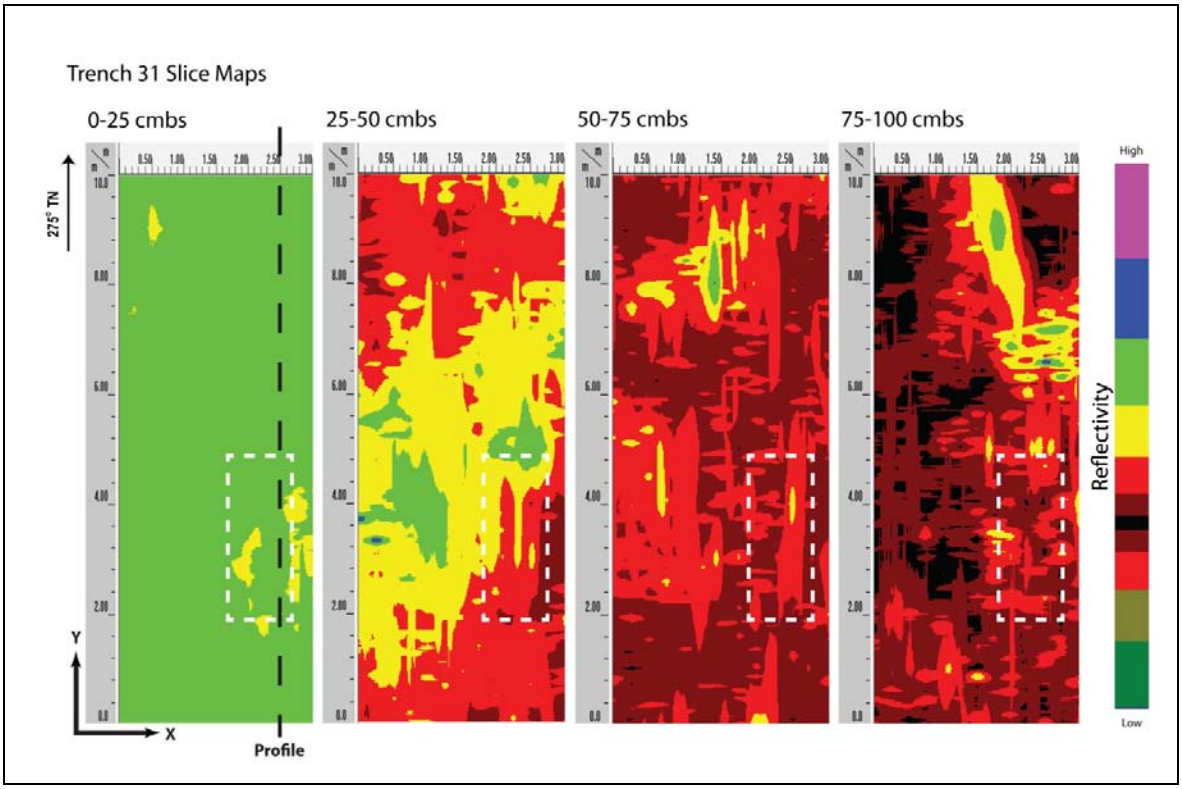

Figure 107. Slice maps of Excavation 31 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a moderate correlation in stratigraphic transitions (Figure 108). Strata Ia and Ib are clearly observed and occur at the ground-truthed depths. The area appears to be heavily disturbed due to the appearance of large hyperbolas on the GPR profile and which was confirmed by excavation. During excavation a utilitity was found within stratum Ie in the northern edge of the excavation at ~50 cmbs but was not observed in the profile. No other discrete objects were observed in the GPR results.

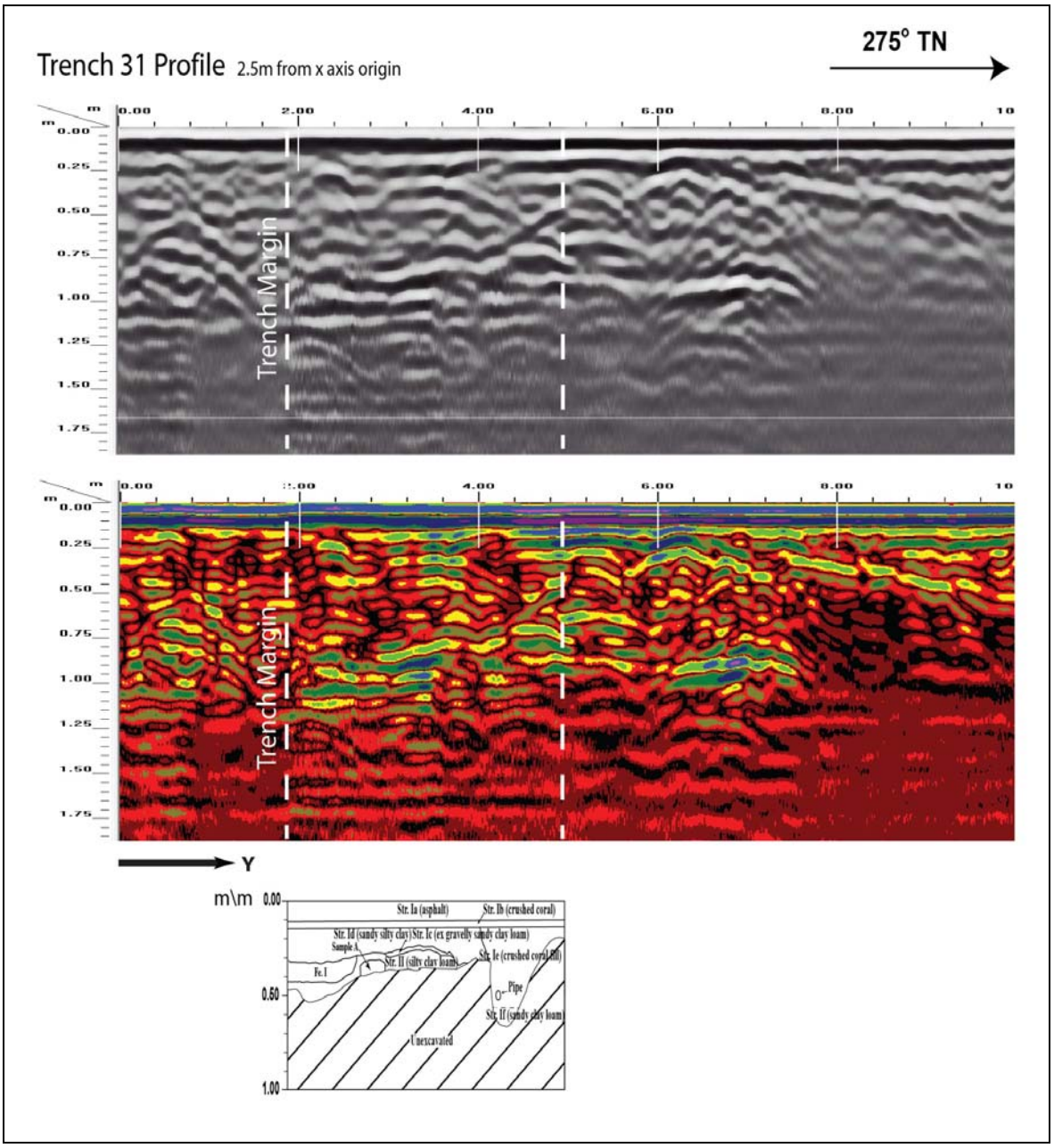

Figure 108. Visual comparison of excavated profile and GPR signal profile of Excavation 31

Excavation 32

Excavation 32 measured 0.6 by 6 meters and was oriented East to West and was located within the Chevron gas station parking lot 7 meters South of Waiwai Loop and 20 meters East of Lagoon Drive. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain line 4 meters to the East, gas and sewer line 5 meters to the North from the East end of the excavation. Several utilities were encountered in the East end of the excavation; 2 water lines approximately 15 cmbs and 2 unknown utilities approximately 45 cmbs.

A review of amplitude slice maps indicates linear features which corresponds to the utilities encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth except for the area that contained utilities. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 109).

GPR depth profiles for Excavation 32 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 110). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 50 cmbs. Several anomalies were observed in the profile which corresponds to the utilities that were encountered during excavation. The maximum depth of clean signal return was approximately 100 cmbs.

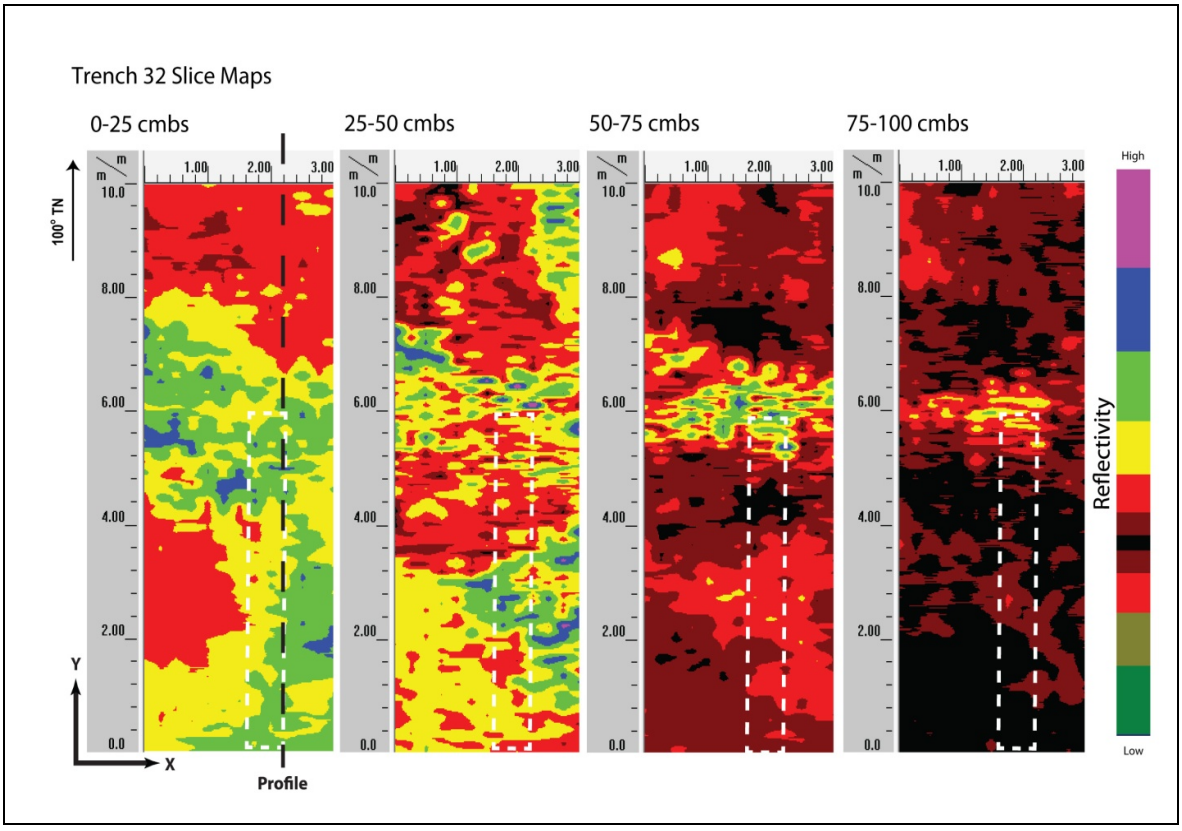

Figure 109. Slice maps for Excavation 32 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a very strong correlation in stratigraphic transitions (Figure 110). Strata Ia through Ic are all clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ib which represents gravel. Several utilitities located in Eastern edge of the excavation are clearly shown in the profile. All other sediment transitions are below the maxium depth of clean signal return. No other discrete objects were observed in the GPR results or subsequent excavation.

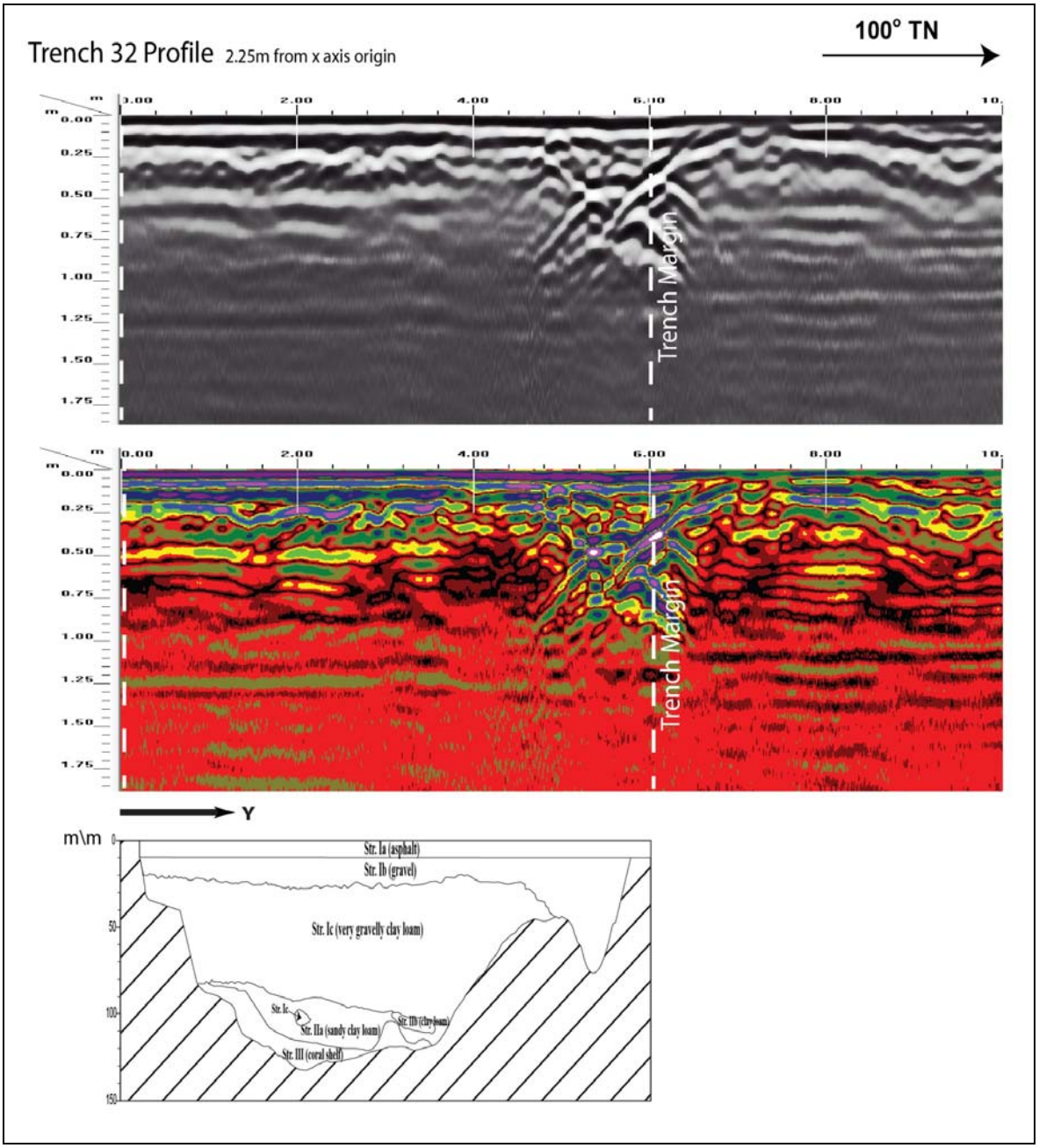

Figure 110. Visual comparison of excavated profile and GPR signal profile of Excavation 32

Excavation 33

Excavation 33 measured 0.6 by 6 meters and was oriented Northwest to Southeast and was located within the Pacific Courier parking lot 13 meters to the East of Lagoon Drive and 19 meters North of Waiwai Loop . The GPR grid measured 3 meters by 8 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water and electric line 13 meters to the West. An electric line was encountered 60 cmbs in the Northwest end of the excavation.

A review of amplitude slice maps indicate a linear feature which corresponds to the utility encountered. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 111).

GPR depth profiles for Excavation 33 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 112). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. An anomaly was observed in the profile and corresponds to the utility encountered during excavation. The maximum depth of clean signal return was approximately 110 cmbs.

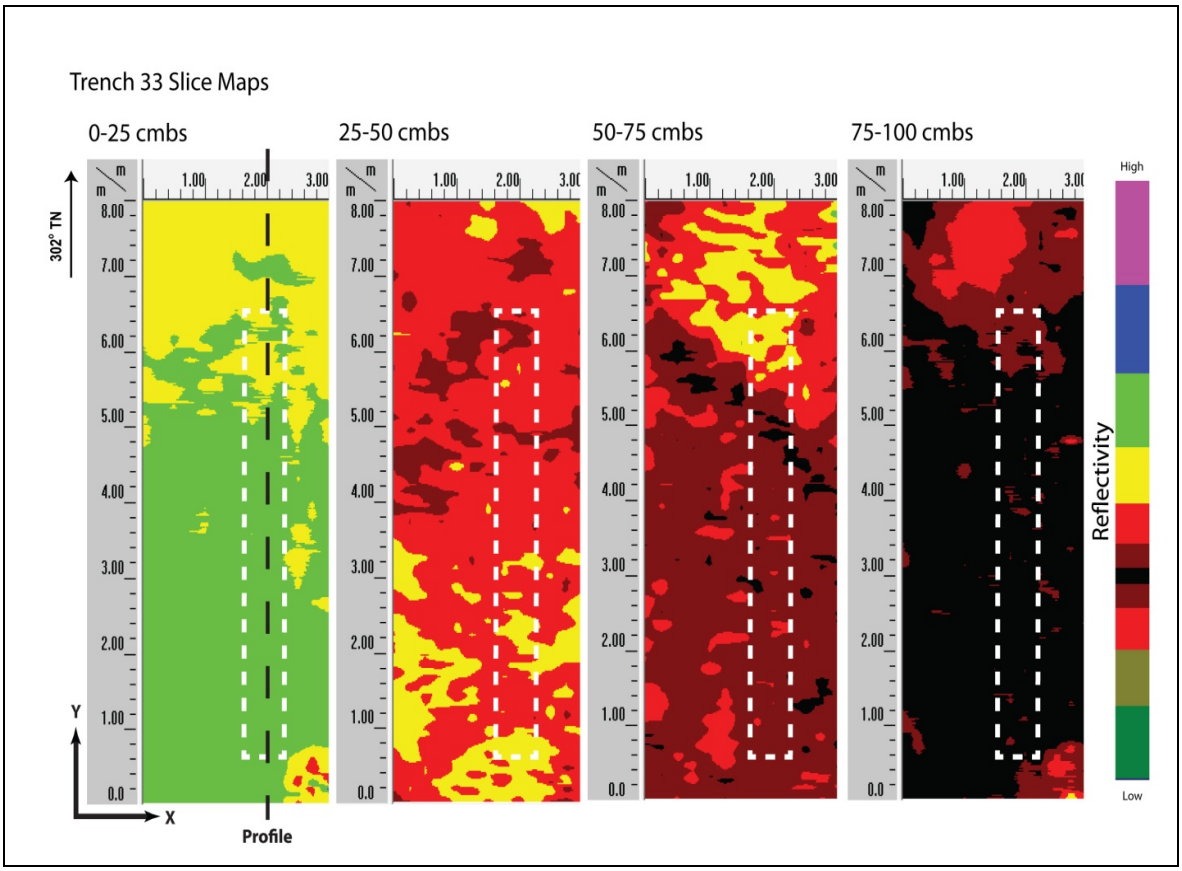

Figure 111. Slice maps for Excavation 33 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 112). Strata Ia to Id are clearly observed and occur at the ground-truthed depths. Textural and reflectivity changes in the form of multiple small hyprbolas and a lower reflectivity are apparent in stratum Ie which was very gravelly to cobbly loam. A utility in the Northwestern end of the excavation is clearly shown in the profile. No discrete objects were observed in the GPR results or subsequent excavation.

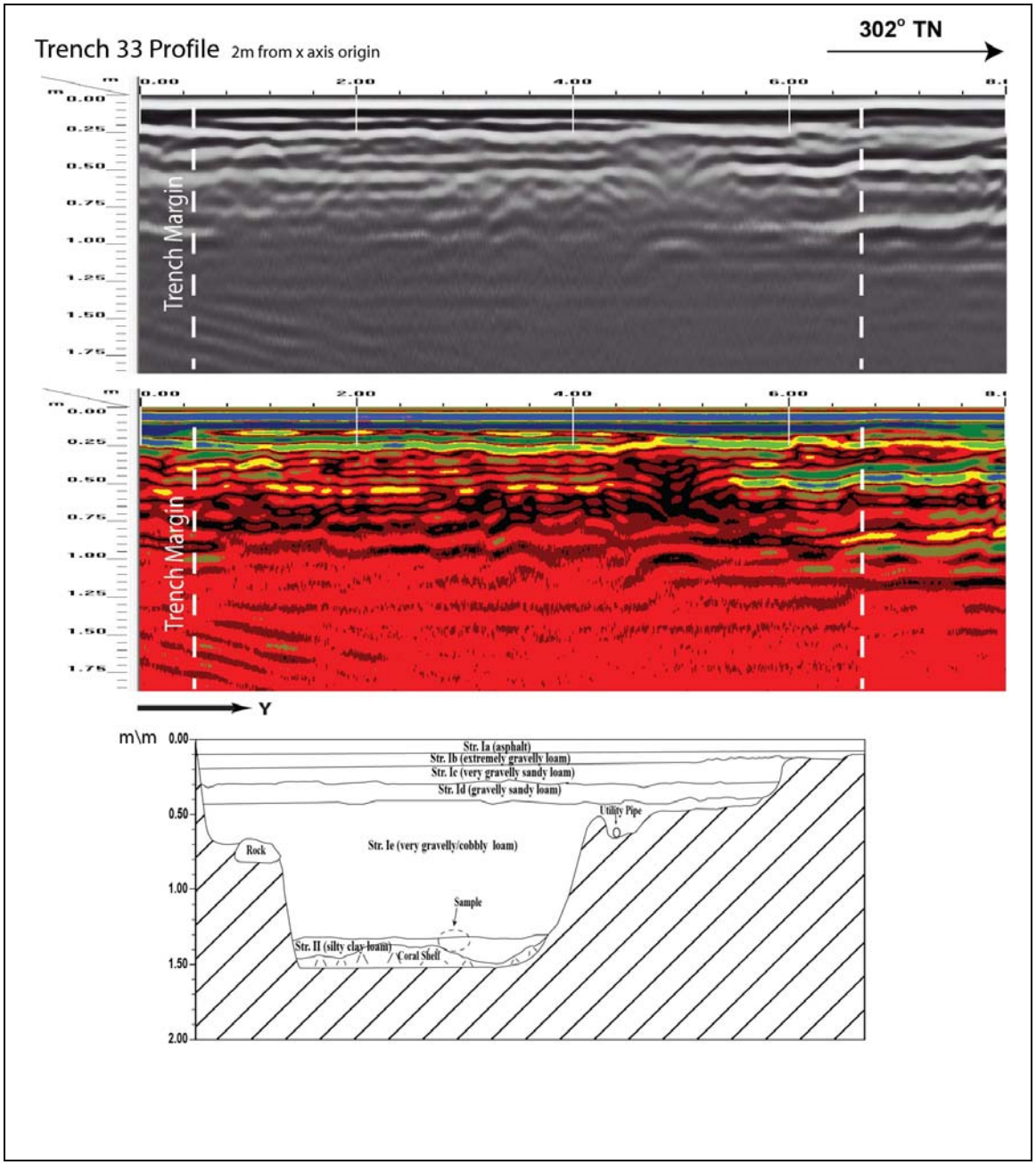

Figure 112. Visual comparison of excavated profile and GPR signal profile of Excavation 33

Excavation 34

Excavation 34 measured 0.6 by 6 meters and was oriented East to West and was located within the Chevron gas station parking lot 14 meters South of Waiwai Loop and 9 meters East of Lagoon Drive. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water and electric line 8 meters to the West. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 75 cmbs (Figure 113)

GPR depth profiles for Excavation 34 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 114). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 40 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 115 cmbs.

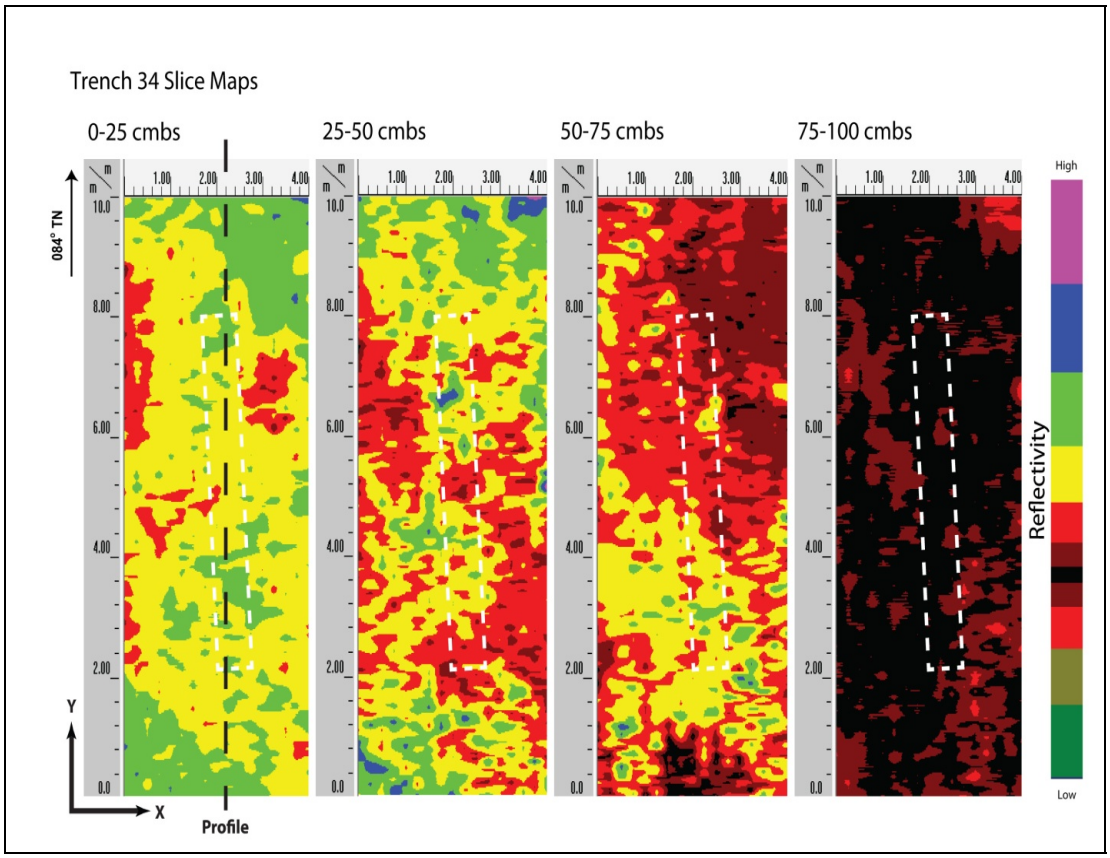

Figure 113. Slice maps of Excavation 34 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 114). Strata Ia to Ib and strata Ib to Ic are clearly observed in the GPR profile and occur at the ground-truthed depths. A change in signal texture is noted around 50 cmbs and may represent the stratigraphic transition to stratum IV. No discrete objects were observed in the GPR results.

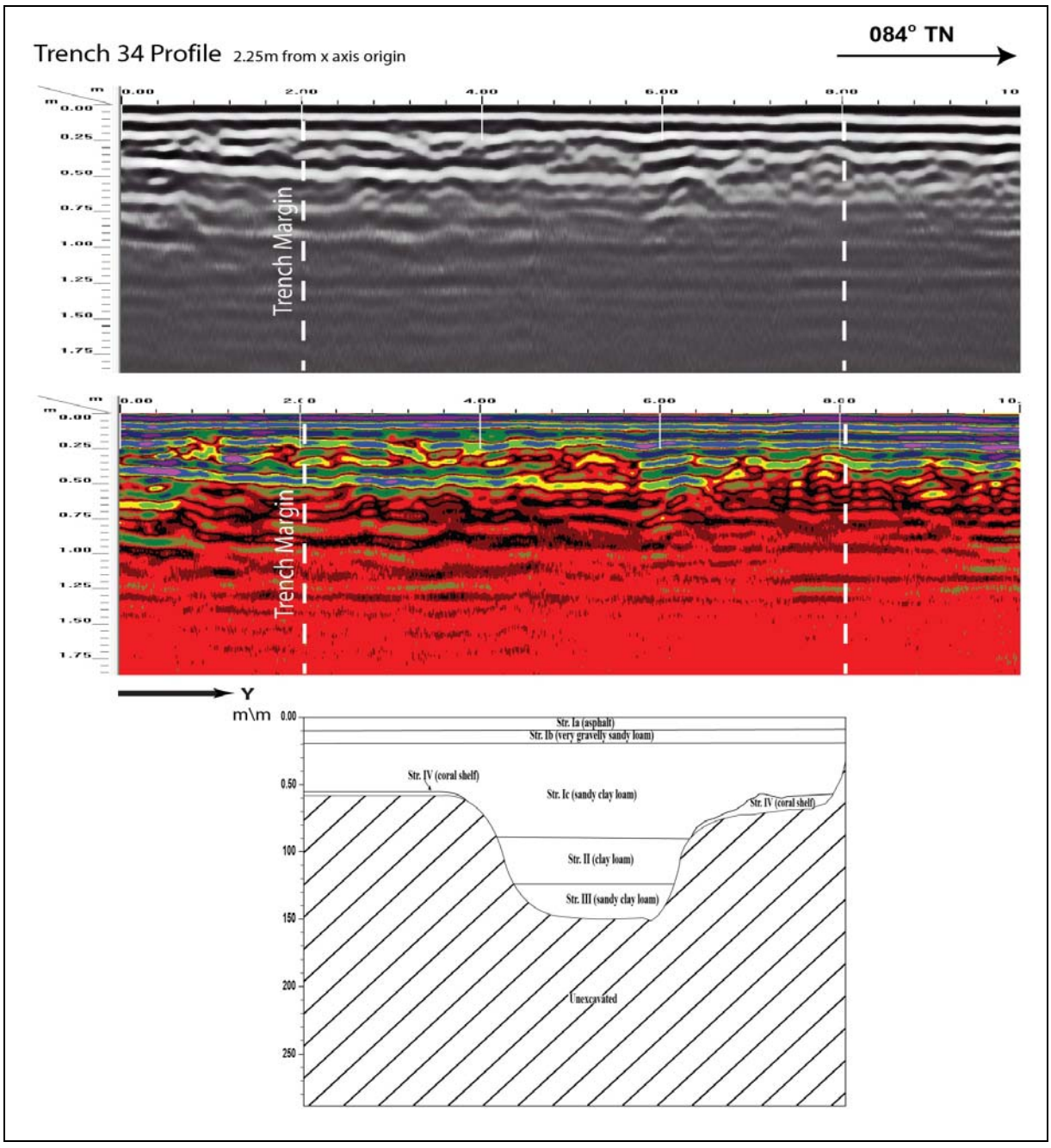

Figure 114. Visual comparison of excavated profile and GPR signal profile of Excavation 34

Excavation 35

Excavation 35 measured 0.6 by 6 meters and was oriented East to West and was located within the road cut of Waiwai Loop 16 meters Northeast of the Chevron gas station and 23 meters Southeast of the Pacific Courier. The GPR grid measured 3 meters by 9 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water line 2 meters to the North and a sewer line 2 meters to the South. No utilties transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 115).

GPR depth profiles for Excavation 35 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 116). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. An anomaly was observed in the profile but was not observed during excavation. The maximum depth of clean signal return was approximately 80 cmbs.

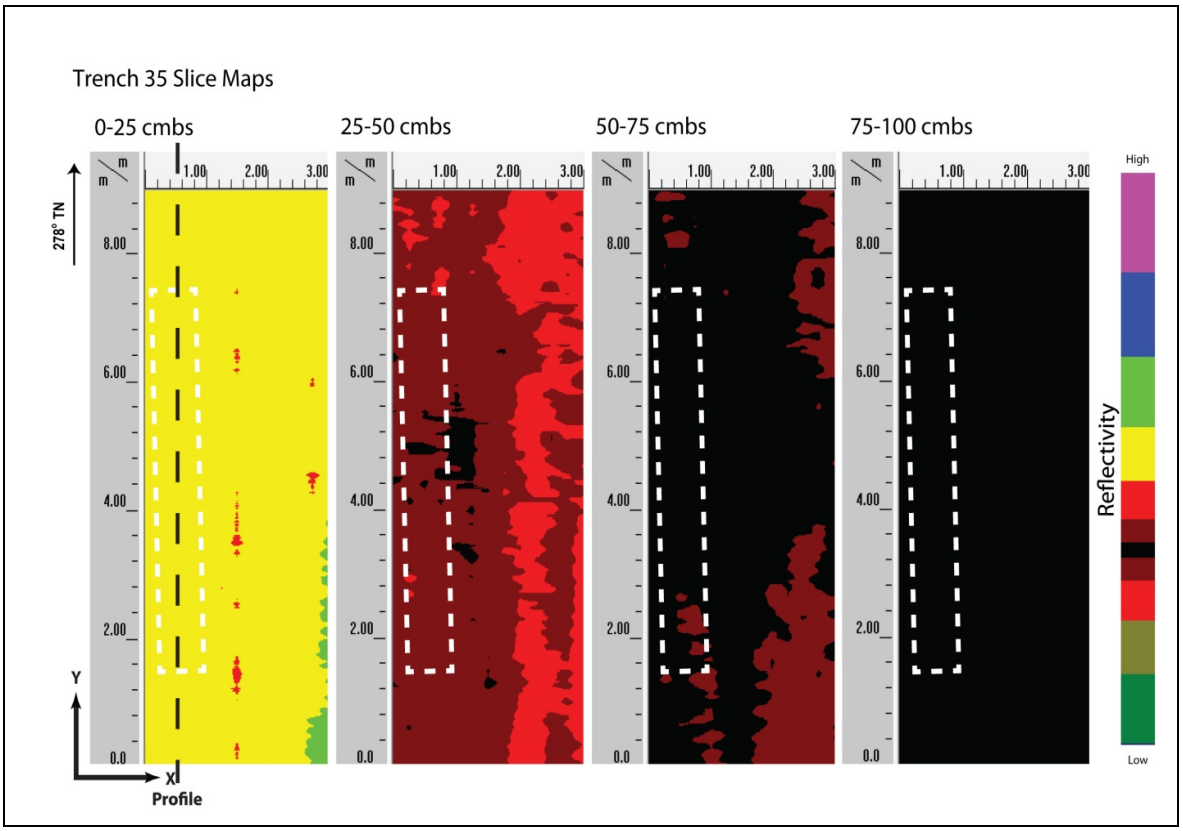

Figure 115. Slice maps of Excavation 35 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a very strong correlation in stratigraphic transitions (Figure 116). Strata Ia through Id are all clearly observed and occur at the ground-truthed depths. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

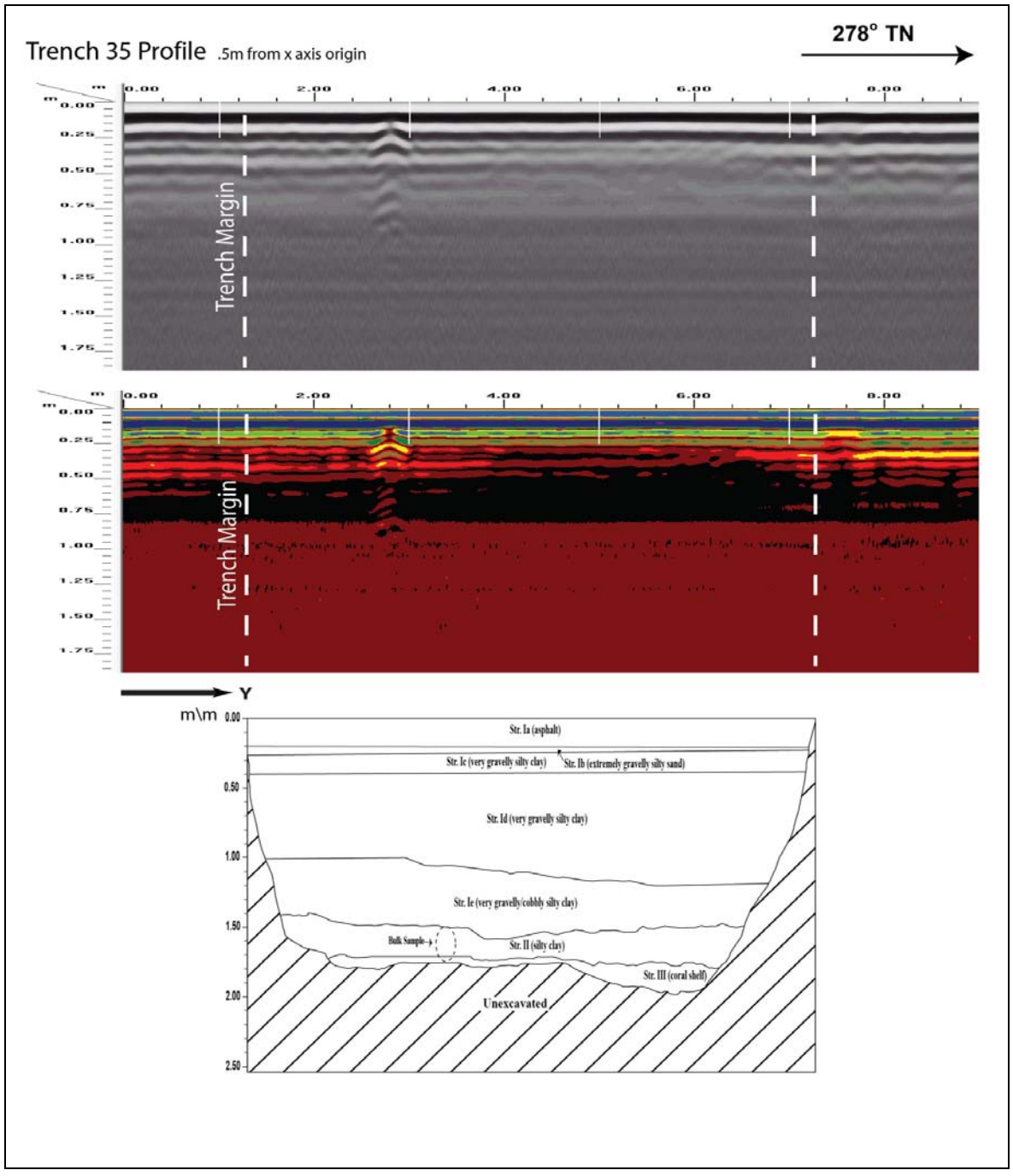

Figure 116. Visual comparison of excavated profile and GPR signal profile of Excavation 35

Excavation 36

Excavation 36 measured 0.6 by 6 meters and was oriented East to West and was located within the Window World Inc. parking lot 6 meters South of Waiwai Loop and 65 meters East of Lagoon Drive. The GPR grid measured 2 meters by 8 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water line 4 meters to the North and sewer line 3 meters to the West. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates a linear features which might indicate the presence of utilities but this feature was not encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 75 cmbs (Figure 117).

GPR depth profiles for Excavation 36 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 118). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 50 cmbs and again around 75 cmbs. An anomaly was observed in the profile but was not encountered while excavating. The maximum depth of clean signal return was approximately 110 cmbs.

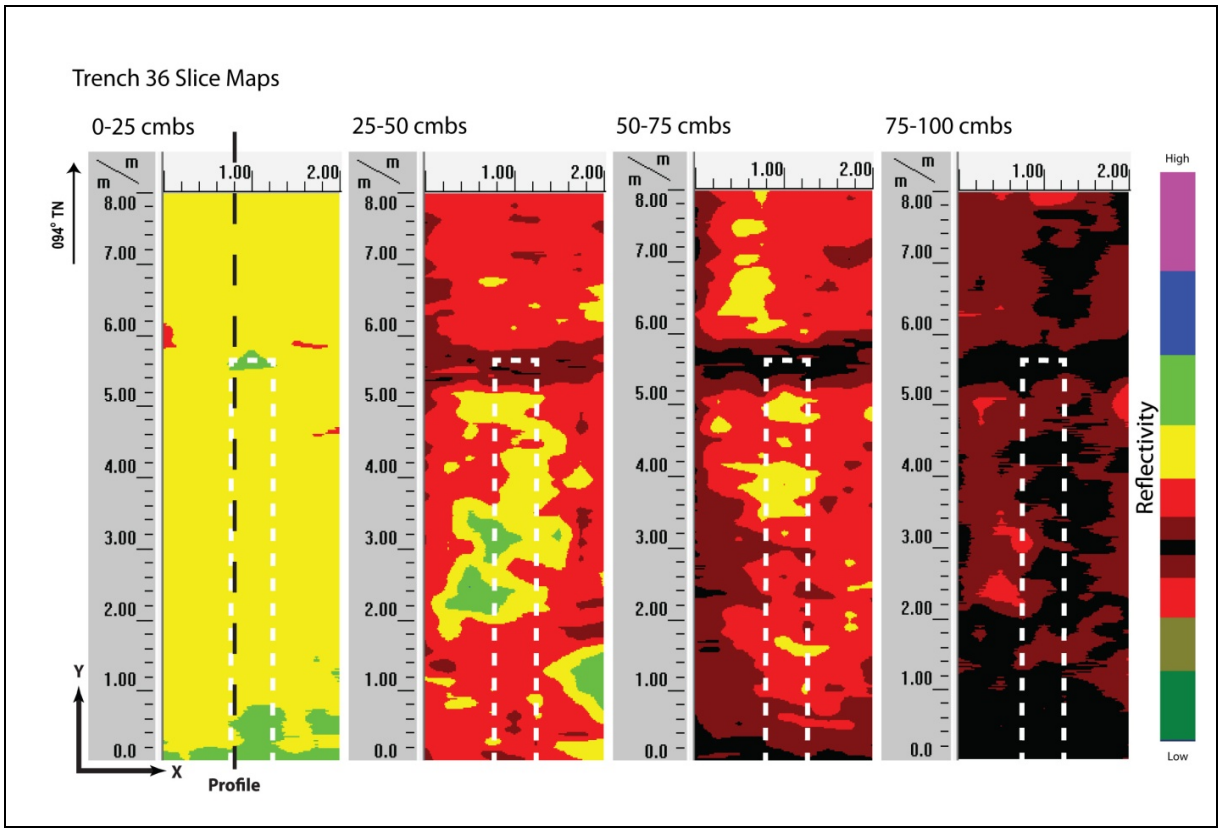

Figure 117. Slice maps of Excavation 36 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 118). Strata Ia through Id are all clearly observed and occur at the ground-truthed depths as highly compacted multiple fill events. A linear feature occurs on the profile along the Eastern end of the excavation but was not ground-truthed and therefore may represent a discrete object. All other sediment transitions are below the maxium depth of clean signal return.

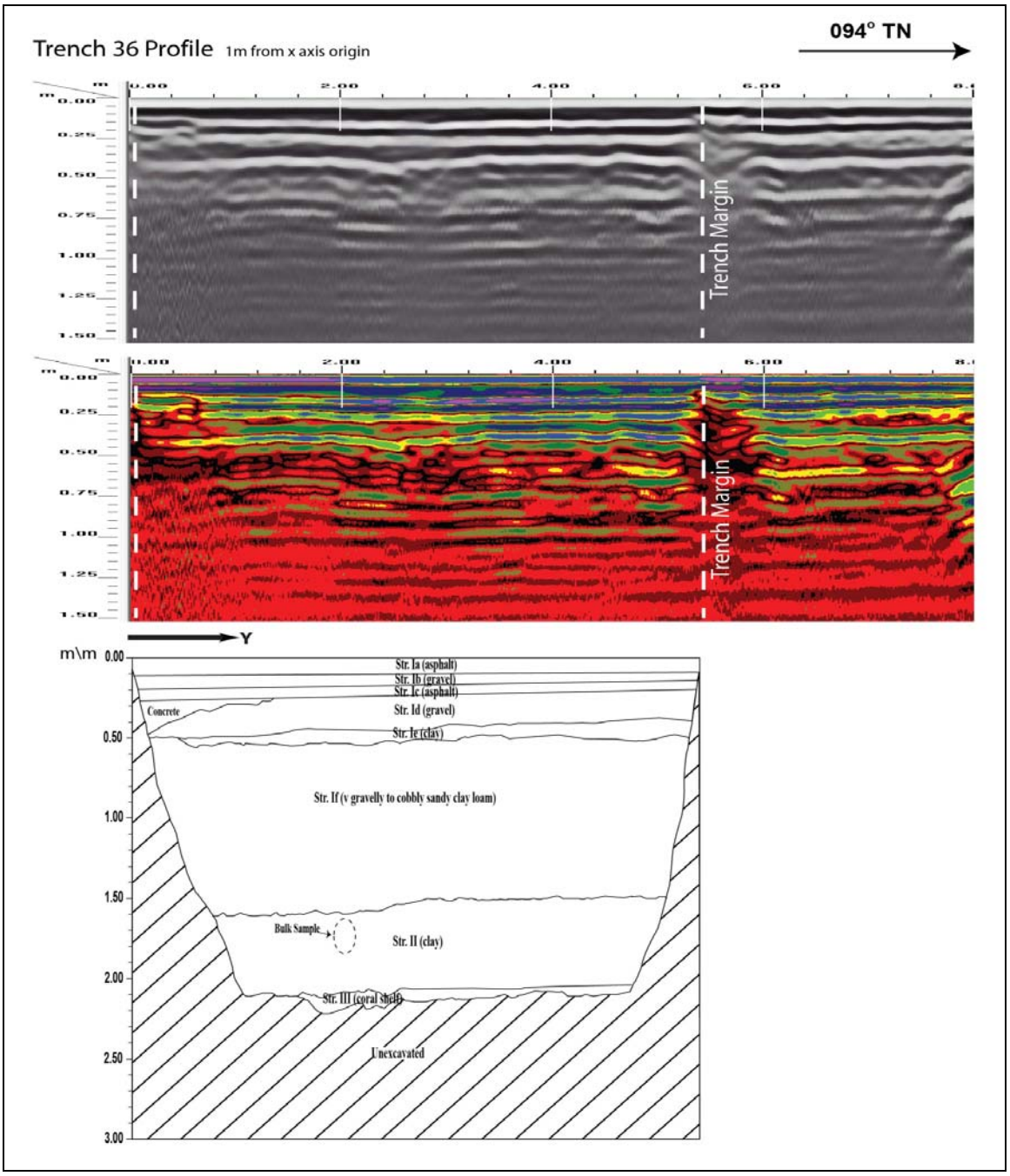

Figure 118. Visual comparison of excavated profile and GPR signal profile of Excavation 36

Excavation 37

Excavation 37 measured 0.9 meters by 3 meters and was oriented North to South and was located within Alert Holdings Group Inc. parking lot 25 meters South of Waiwai Loop and 62 meters Northwest of Keehi Lagoon Park. The GPR grid measured 3 meters by 8 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: power lines .5 meters to the South and 2 meters to the North. A 3” PVC Utility was encountered 76 cmbs running East to West in the middle of the excavation.

A review of amplitude slice maps does not clearly indicate any linear features although a utility was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 119).

GPR depth profiles for Excavation 37 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 120). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 40 cmbs. An anomaly was observed in the profile and it corresponds to the utility which was encountered during excavation. The maximum depth of clean signal return was approximately 90 cmbs.

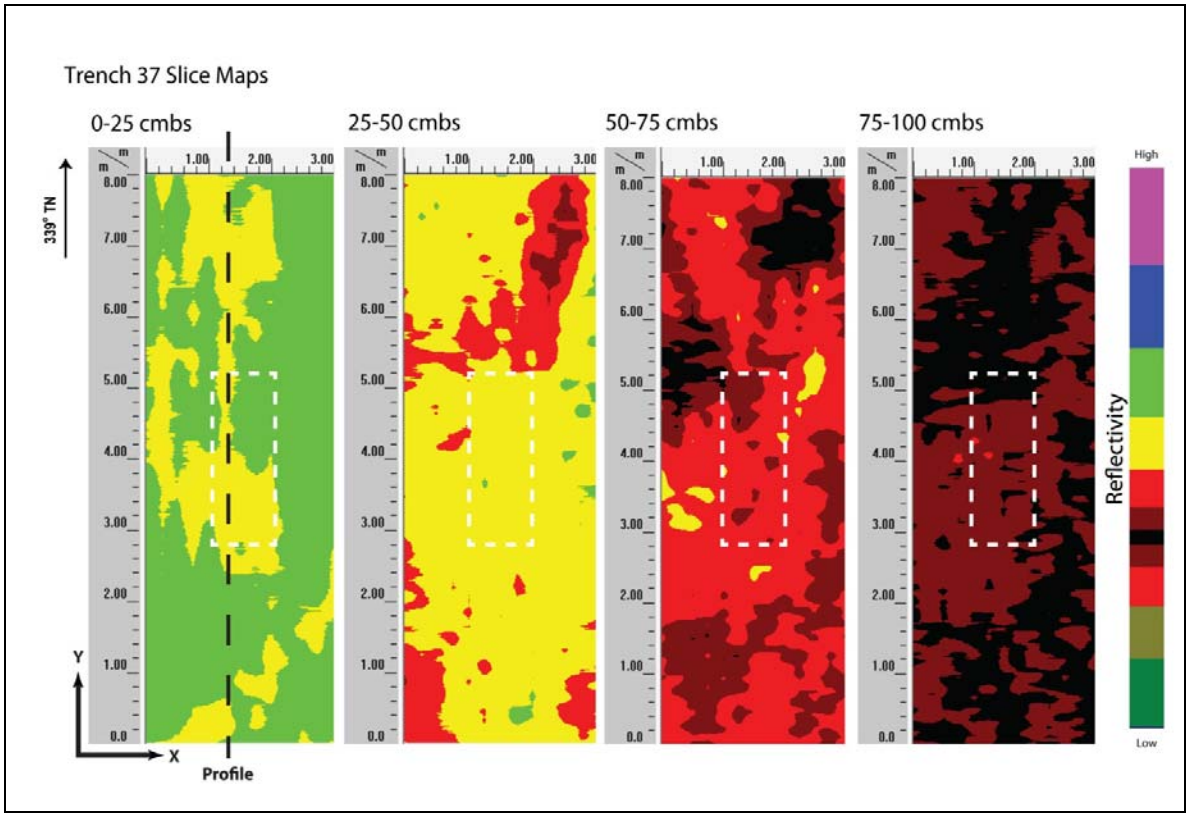

Figure 119. Slice maps of Excavation 37 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 120). Strata Ia through Ic are all clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyperbolas are apparent in stratum Ic which was gravelly loam. During excavation a utilitity was found within stratum Ic in the middle of the excavation ~76 cmbs and this was observed as a large hyperbola in the profile. All other sediment transitions are below the maxium depth of clean signal return. No other discrete objects were observed in the GPR results or subsequent excavation.

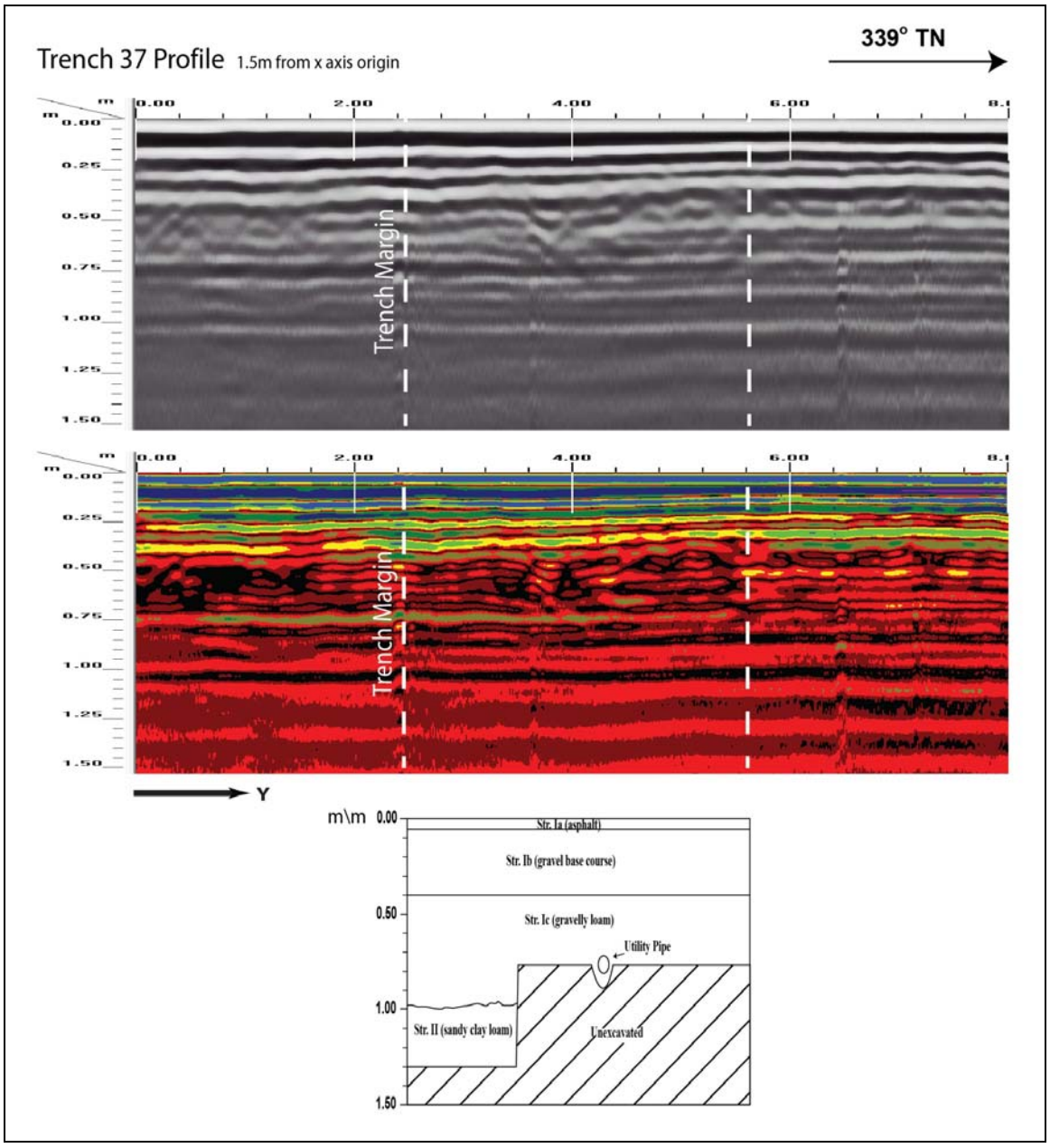

Figure 120. Visual comparison of excavated profile and GPR signal profile of Excavation 37

Excavation 38

Excavation 38 measured 0.9 meters by 3 meters and was oriented Northeast to Southwest and was located within a grassy median 5 meters North of Keehi Lagoon Park parking lot and 71 meters Southeast of Waiwai Loop. Alert Holdings Group Inc. was 11 meters Northwest of the excavation. The GPR grid measured 5 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include a sewer line 6 meters to the West. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 121).

GPR depth profiles for Excavation 38 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 122). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 15 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 100 cmbs.

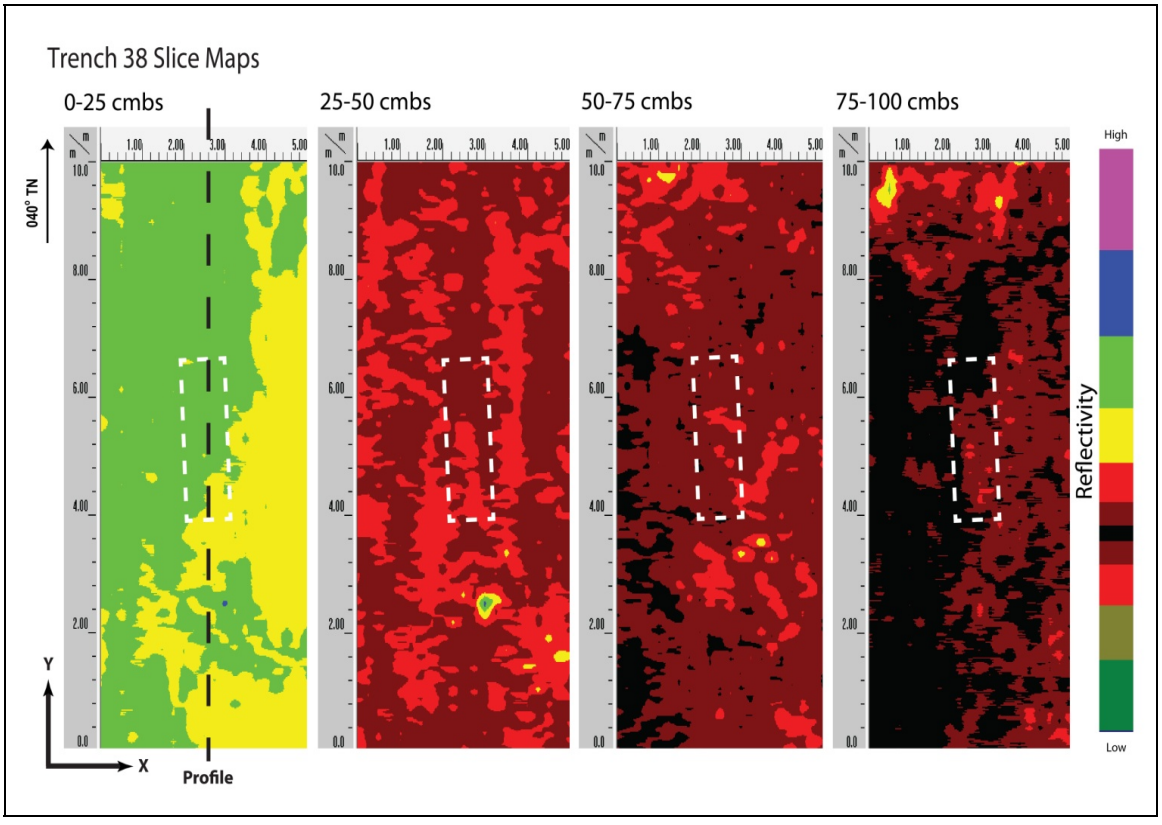

Figure 121. Slice maps of Excavation 38 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 122). Strata Ia through Ib are all clearly observed and occur near ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Id which was crushed coral.All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

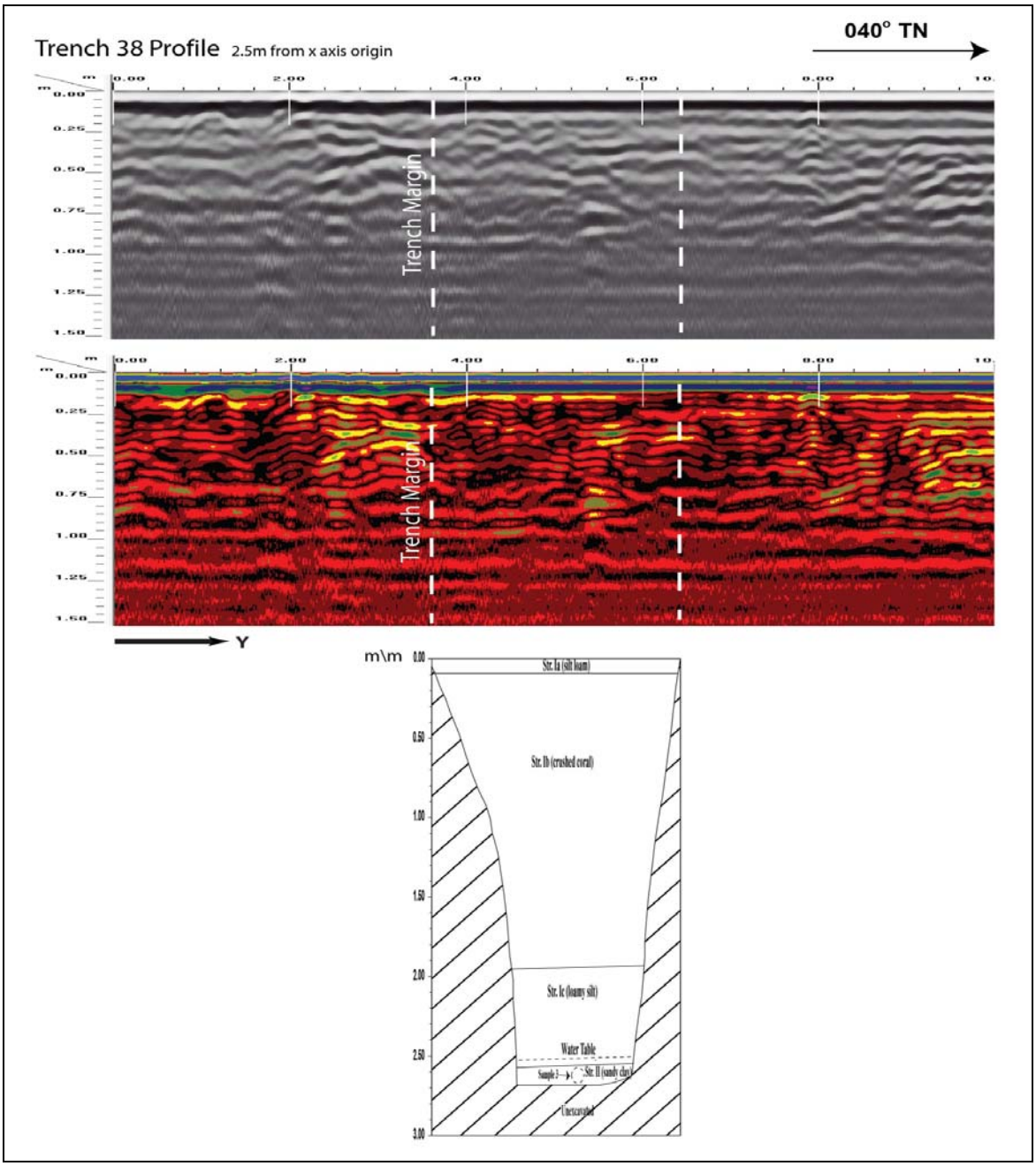

Figure 122. Visual comparison of excavated profile and GPR signal profile of Excavation 38

Excavation 39

Excavation 39 measured 0.9 meters by 3 meters and was oriented East to West and was located within a grassy field 16 meters North of Leehi Lahoon Park parking lot and 62 meters South of Nimitz Highway. Leehi Lagoon Park tennis courts were 24 meters to the West of the excavation. The GPR grid measured 5 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water lines 1 meter to the South, 4 meters to the West and 10 meters to the North. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicate a linear feature which might indicate the presence of utilities but was not within the excavation area. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 123).

GPR depth profiles for Excavation 39 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 124). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 20-25 cmbs and again around 90 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 110 cmbs.

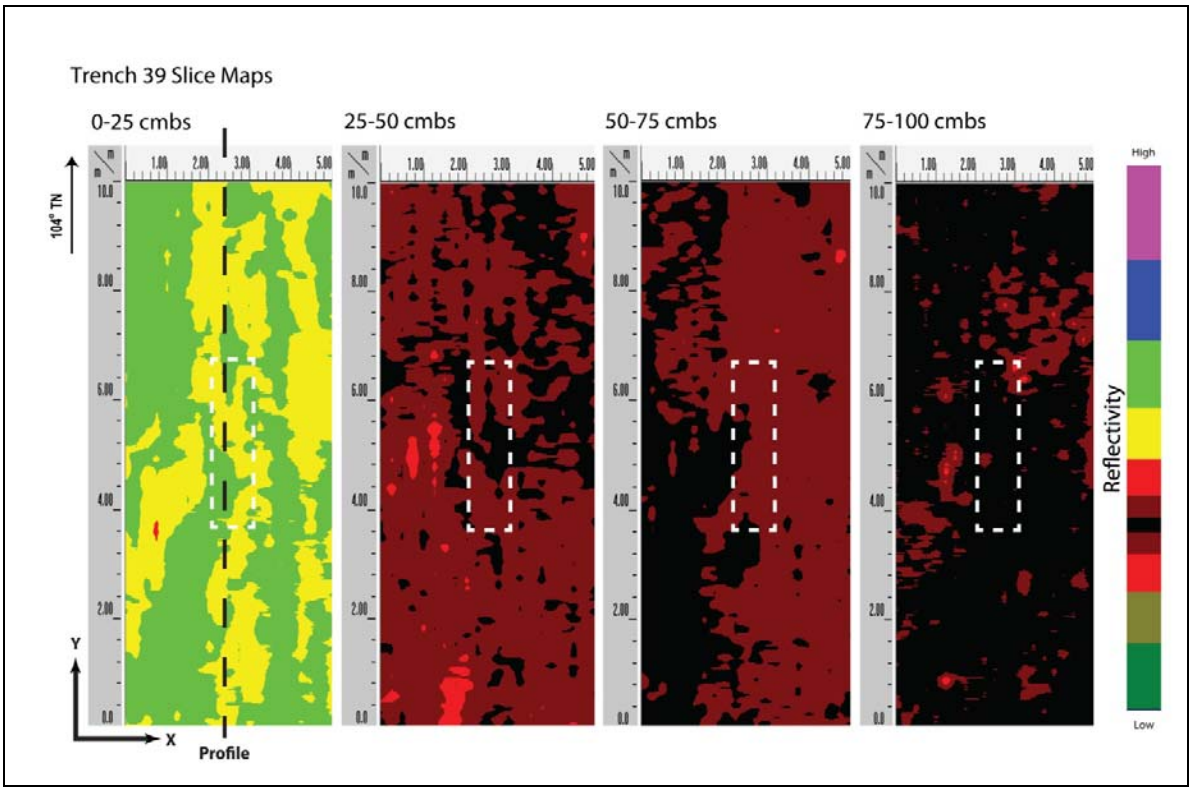

Figure 123. Slice maps of Excavation 39 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 124). Strata Ia through Ib are all clearly observed and occur at ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Ic which was very gravelly sandy loam.All other sediment transitions are below the maxium depth of clean signal return. An area higher in reflectivity was observed past the Eastern end of the excavation at ~ 75cmbs on the profile but was not ground-truthed and therefore may represent a discrete object.

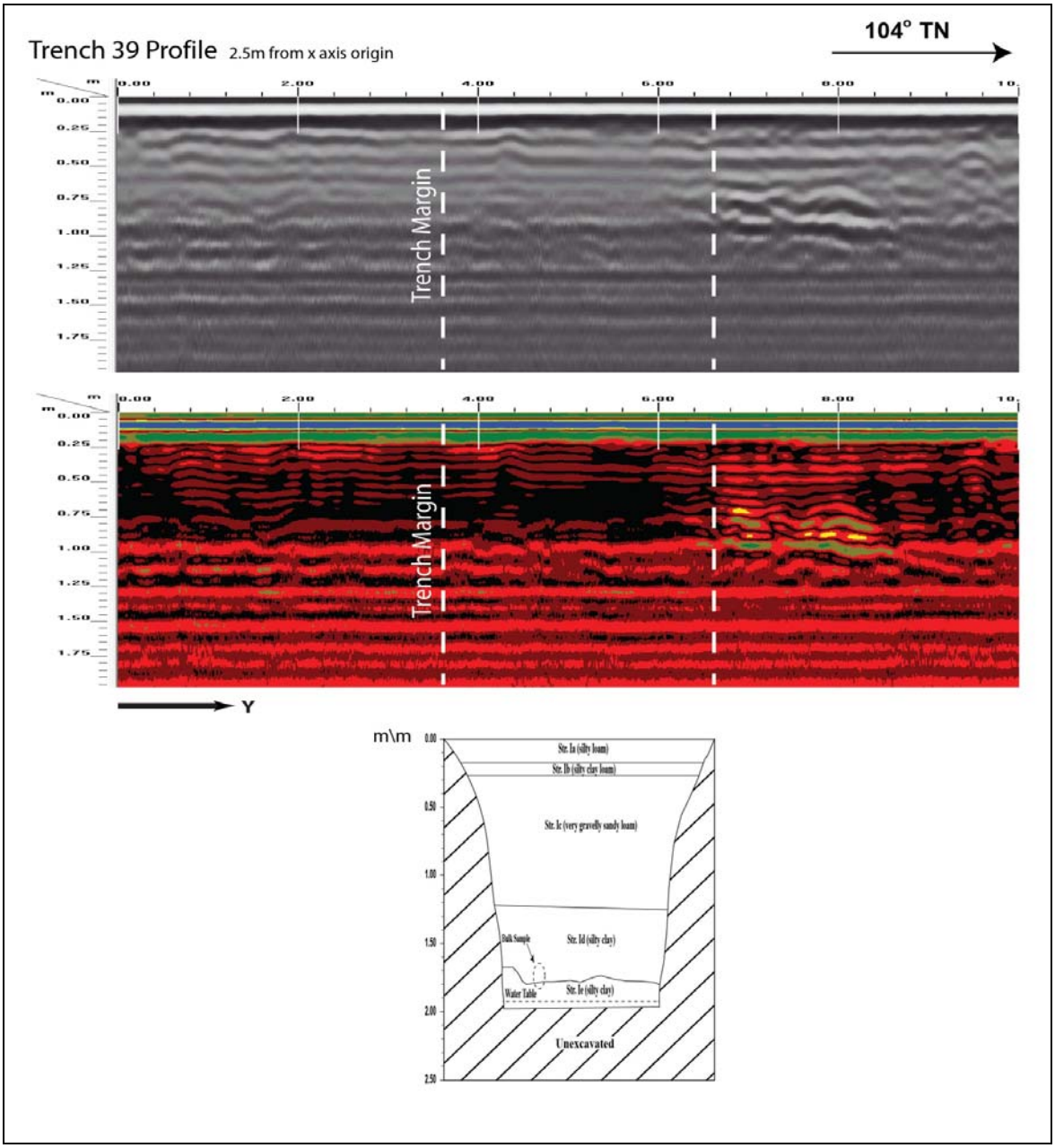

Figure 124. Visual comparison of excavated profile and GPR signal profile of Excavated 39

Excavation 40

Excavation 40 measured 0.9 meters by 3 meters and was oriented Northwest to Southeast and was located within the grassy area between the on and off ramps of Nimitz Highway with Kalihi Stream 144 meters to the Southeast and Moanalua Stream 190 meters to the Southwest. The GPR grid measured 3 meters by 9 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: power line 3 meters to the North. No utilities transected the GPR grid or trench location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is not uniform throughout the grid and has an increase around 75 cmbs but excavation ceased around 40 cmbs due to the presence of the water table. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs and increases again around 75 cmbs (Figure 125).

GPR depth profiles for Excavation 40 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 126). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 150 cmbs.

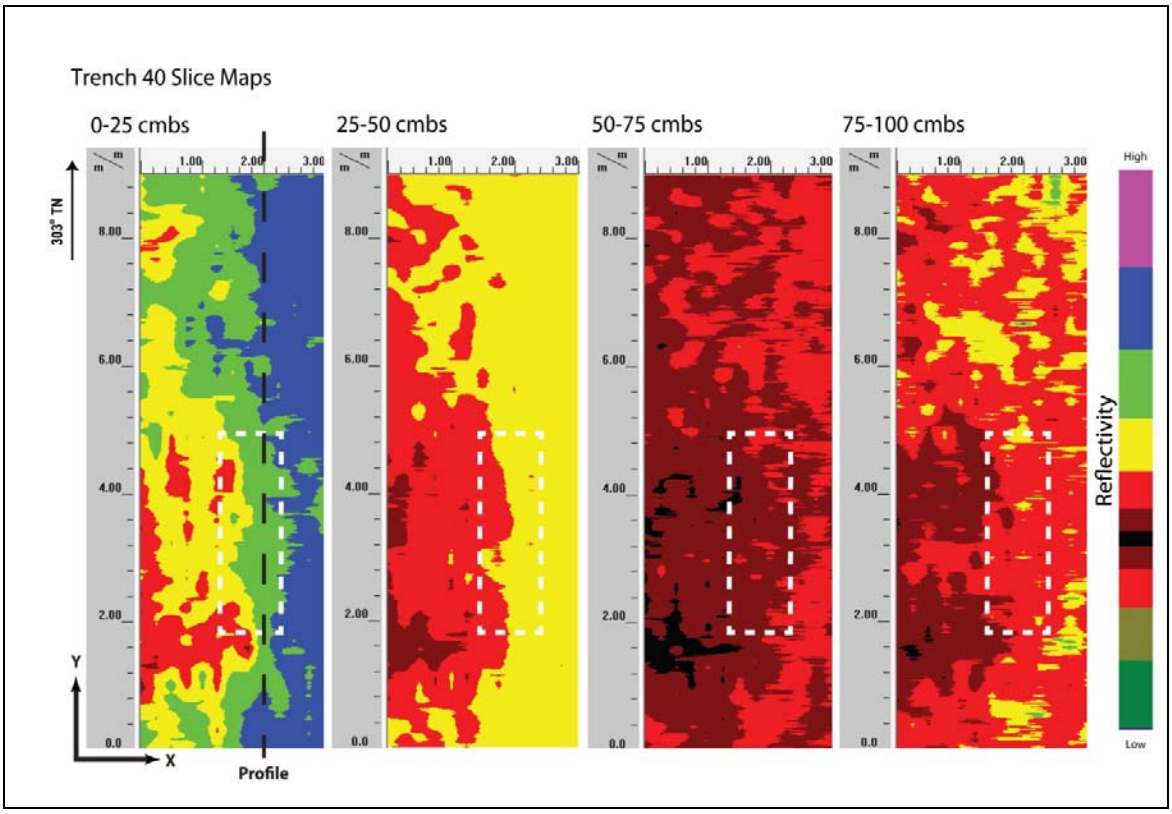

Figure 125. Slice maps of Excavation 40 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a weak correlation in stratigraphic transitions (Figure 126). Strata Ia to Ib are not clearly shown in the GPR profile. A change in reflectivity occurs around 25 cmbs which suggests a change in stratigraphy but when ground-truthed this was not accurate. An area higher in reflectivity was observed around 80 cmbs on the profile but was not ground-truthed and therefore may represent a discrete object.

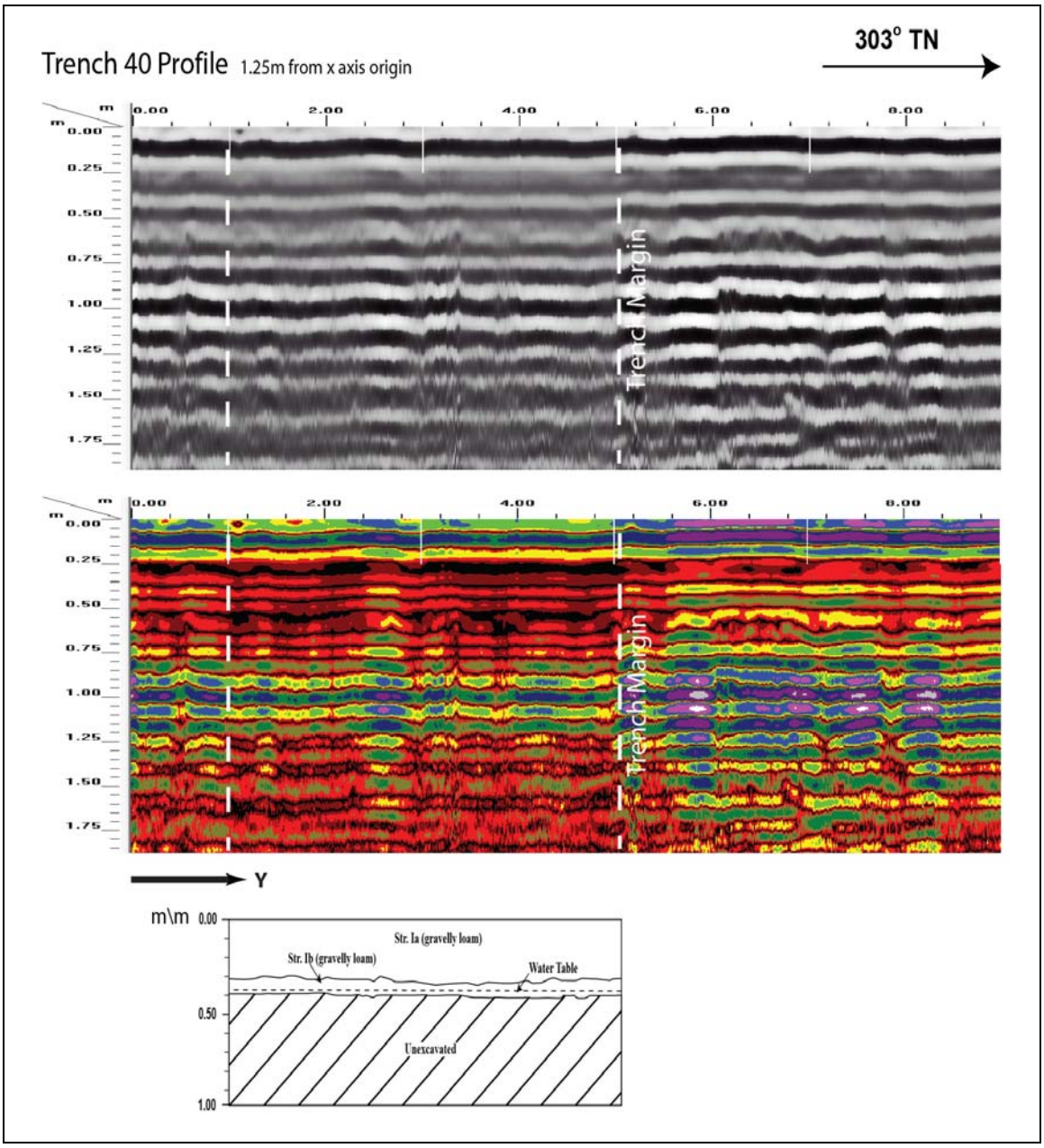

Figure 126. Visual comparison of excavated profile and GPR signal profile of Excavation 40

Excavation 41

Excavation 41 measured 0.9 meters by 3 meters and was oriented North to South and was located within the Honolulu International Airport's Lei Stands parking lot 51 meters to the South of Ala Onaona Street and 80 meters to the West of Ala Auana Street. The Lei Stands were 12 meters to the North of the excavation. The GPR grid measured 3 meters by 6 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: sewer lines 6 meters to the East and 5 meters to the South. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 127).

GPR depth profiles for Excavation 41 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 128). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 15 cmbs and again around 60 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 130 cmbs.

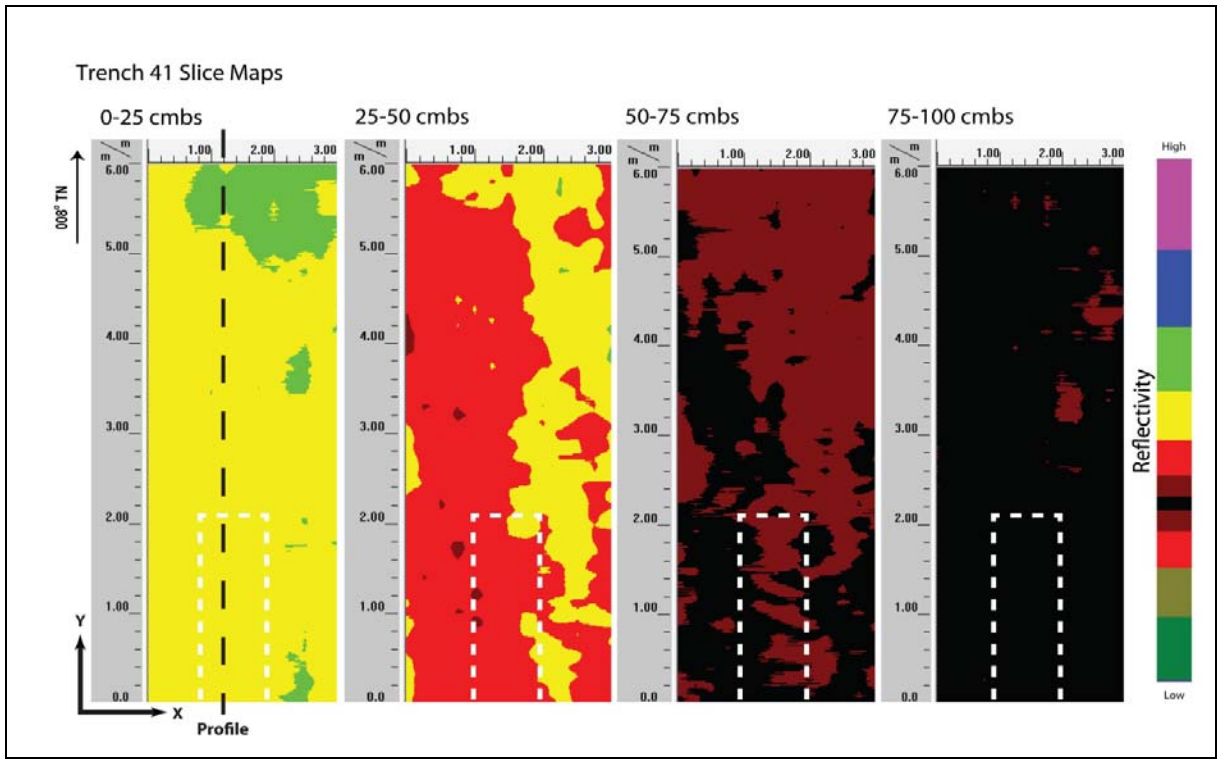

Figure 127. Slice maps of Excavation 41 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a very strong correlation in stratigraphic transitions (Figure 128). Strata Ia through Id are all clearly observed and occur at the ground-truthed depths. Textural changes in the form of multiple small hyprbolas are apparent in stratum Id which represents gravelly sandy loam. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

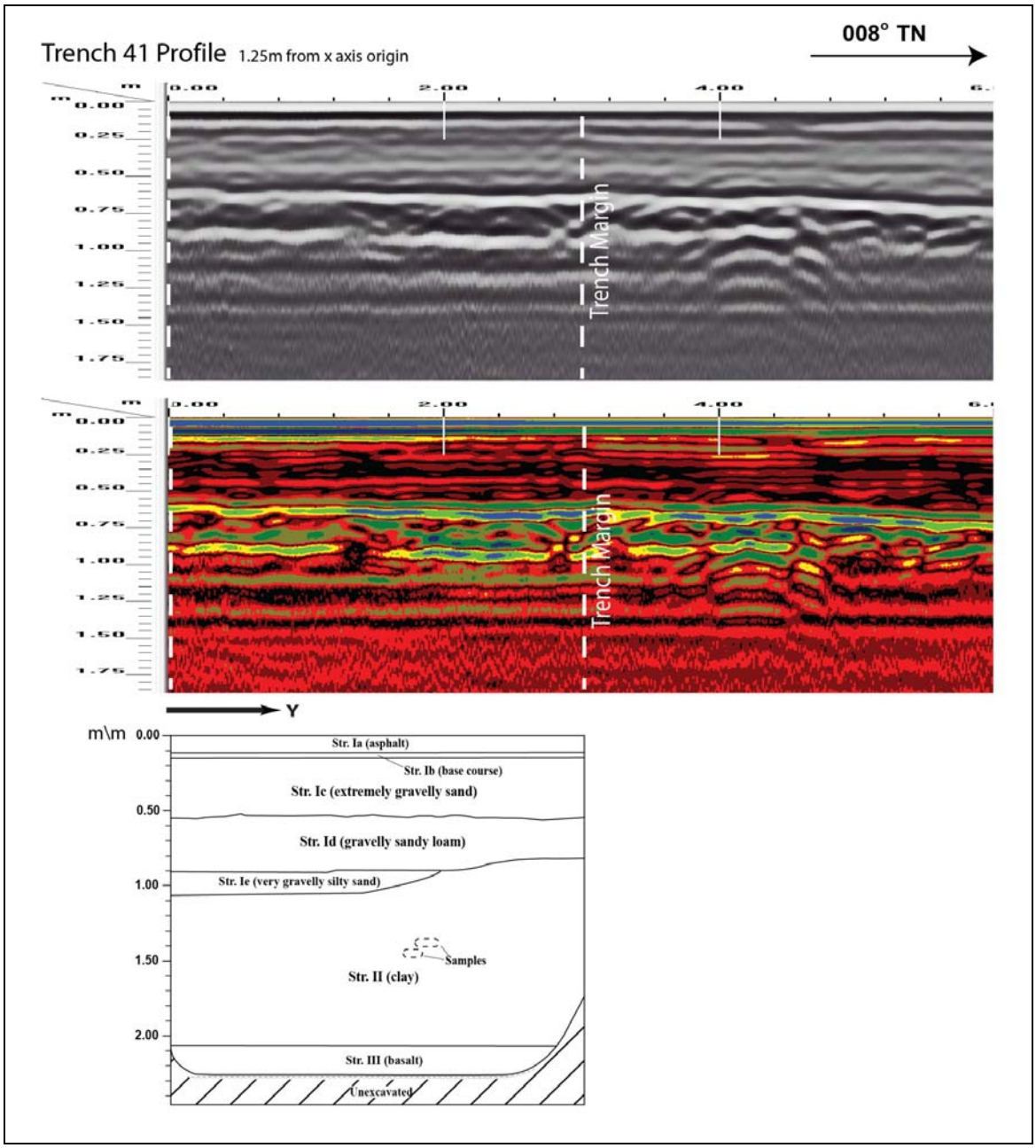

Figure 128. Visual comparison of excavated profile and GPR signal profile of Excavation 41

Excavation 42

Excavation 42 measured 0.9 meters by 3 meters and was oriented North to South and was located within the economy parking lot at the Honolulu International Airport 53 meters South of Ala Onaona Street and approximately 18 meters East of Ala Auana Street. The Lei Stands were 39 meters to the Northwest of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include a drain line 5 meters to the West. No utilties transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs and increases again around 75 cmbs (Figure 129).

GPR depth profiles for Excavation 42 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 130). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25-30 cmbs and again around 60 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 150 cmbs.

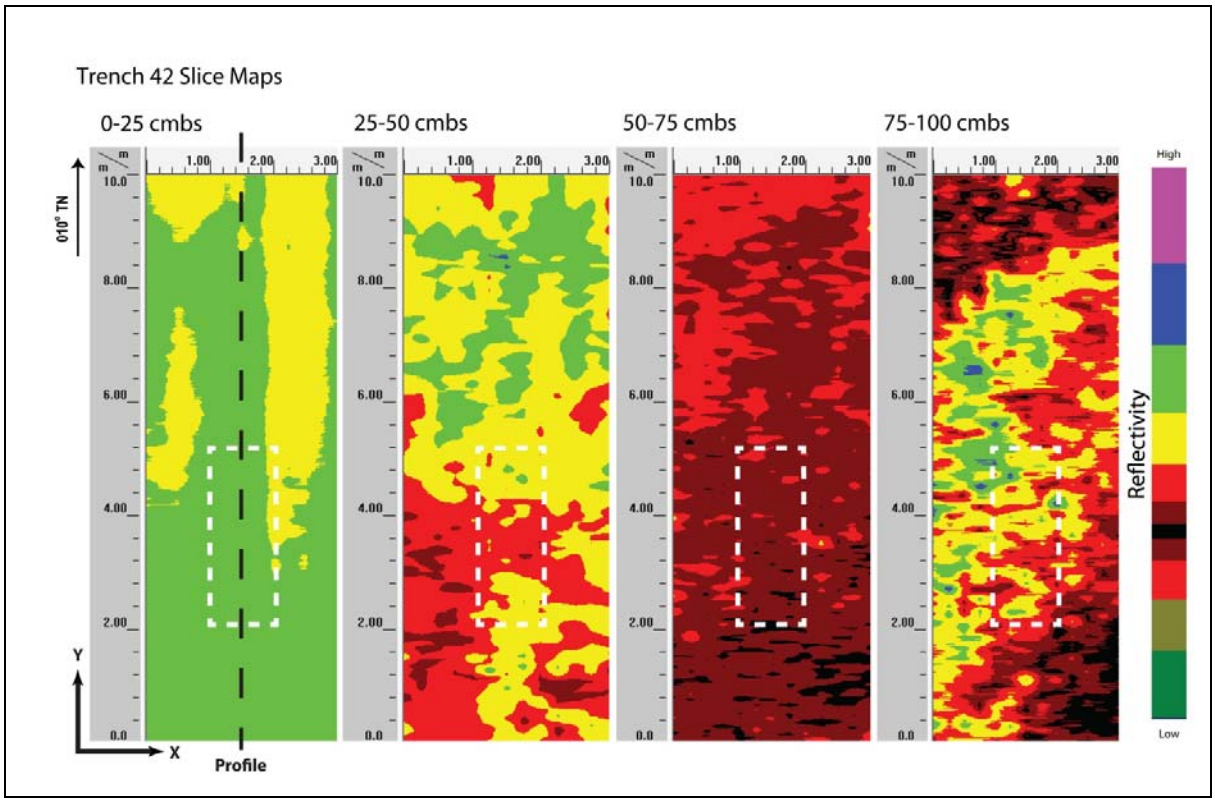

Figure 129. Slice maps of Excavation 42 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 130). Strata Ia to Ib and Ib to Ic are observed in the GPR profile and occur at the ground-truthed depths. An area of higher reflectivity occurs at 75-100 cmbs but nothing was encountered during excavation. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

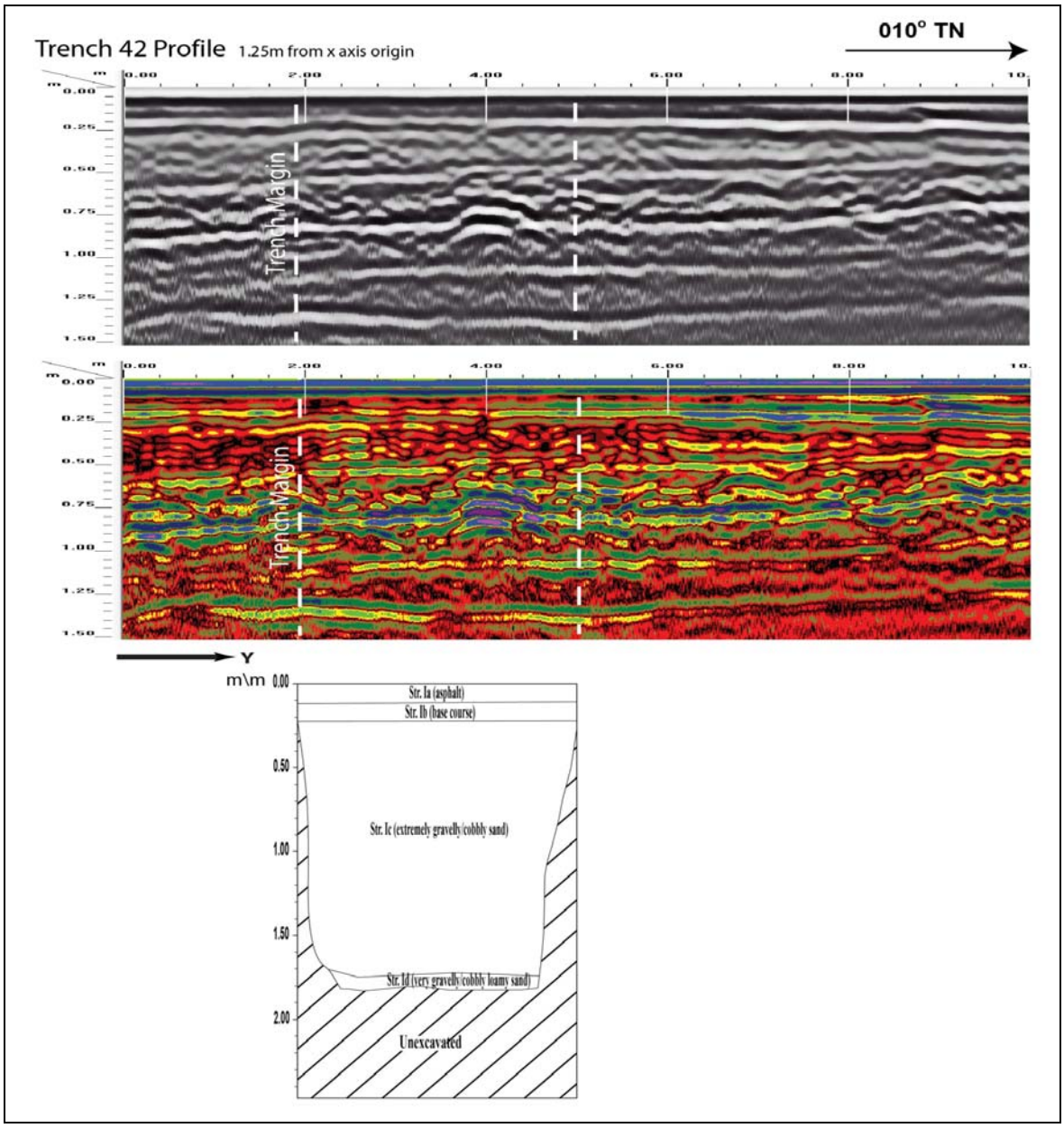

Figure 130. Visual comparison of excavated profile and GPR signal profile of Excavation 42

Excavation 43

Excavation 43 measured 0.6 meters by 6 meters and was oriented North to South and was located within the economy parking lot at the Honolulu International Airport 63 meters South of Ala Onaona Street and approximately 21 meters East of Ala Auana Street. The Lei Stands were 48 meters to the Northwest of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain line 6.5 meters to the West. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs (Figure 131).

GPR depth profiles for Excavation 43 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 132). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 20-25 cmbs. No utilities were observed in the profile. The maximum depth of clean signal return was approximately 90 cmbs.

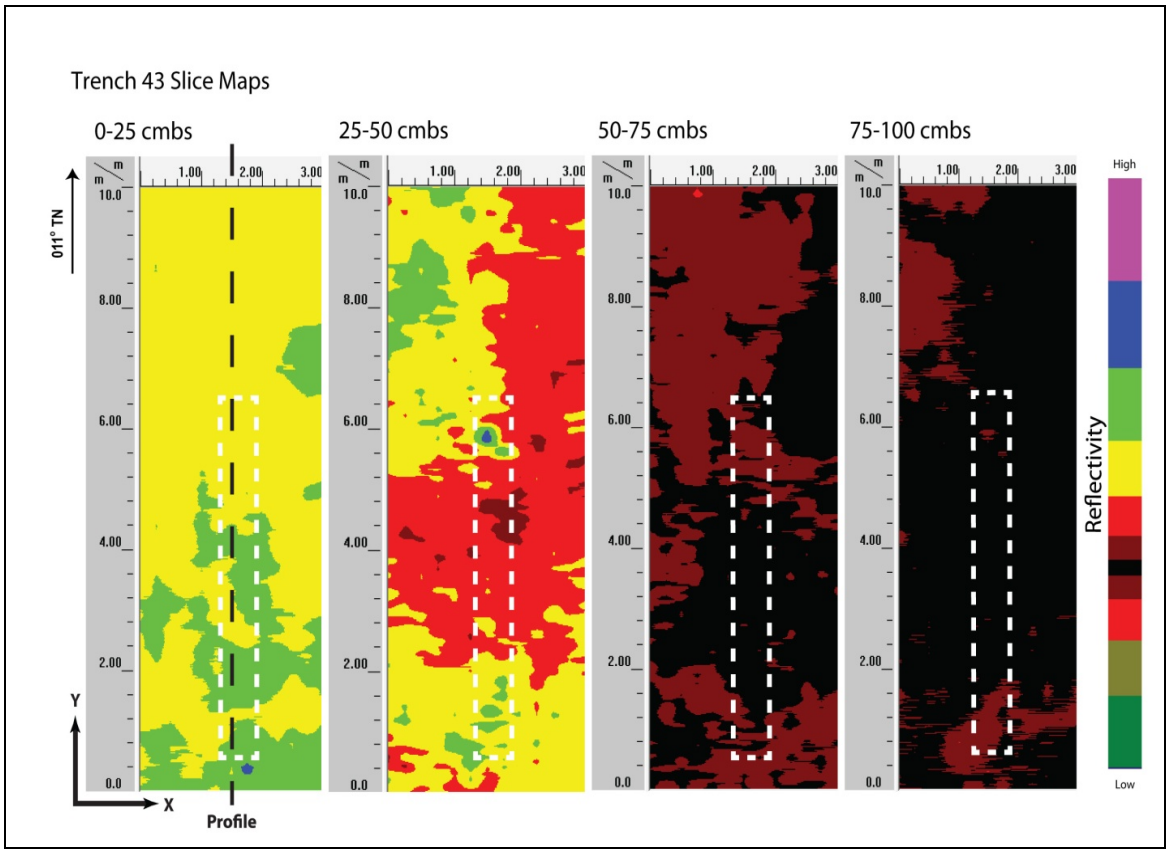

Figure 131. Slice maps of Excavation 43 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 132). Strata Ia through Ic are all clearly observed and occur at the ground-truthed depths as highly compacted multiple fill events. Textural changes in the form of multiple small hyprbolas are apparent in stratum Id which represents very gravelly to cobbly sandy loam. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

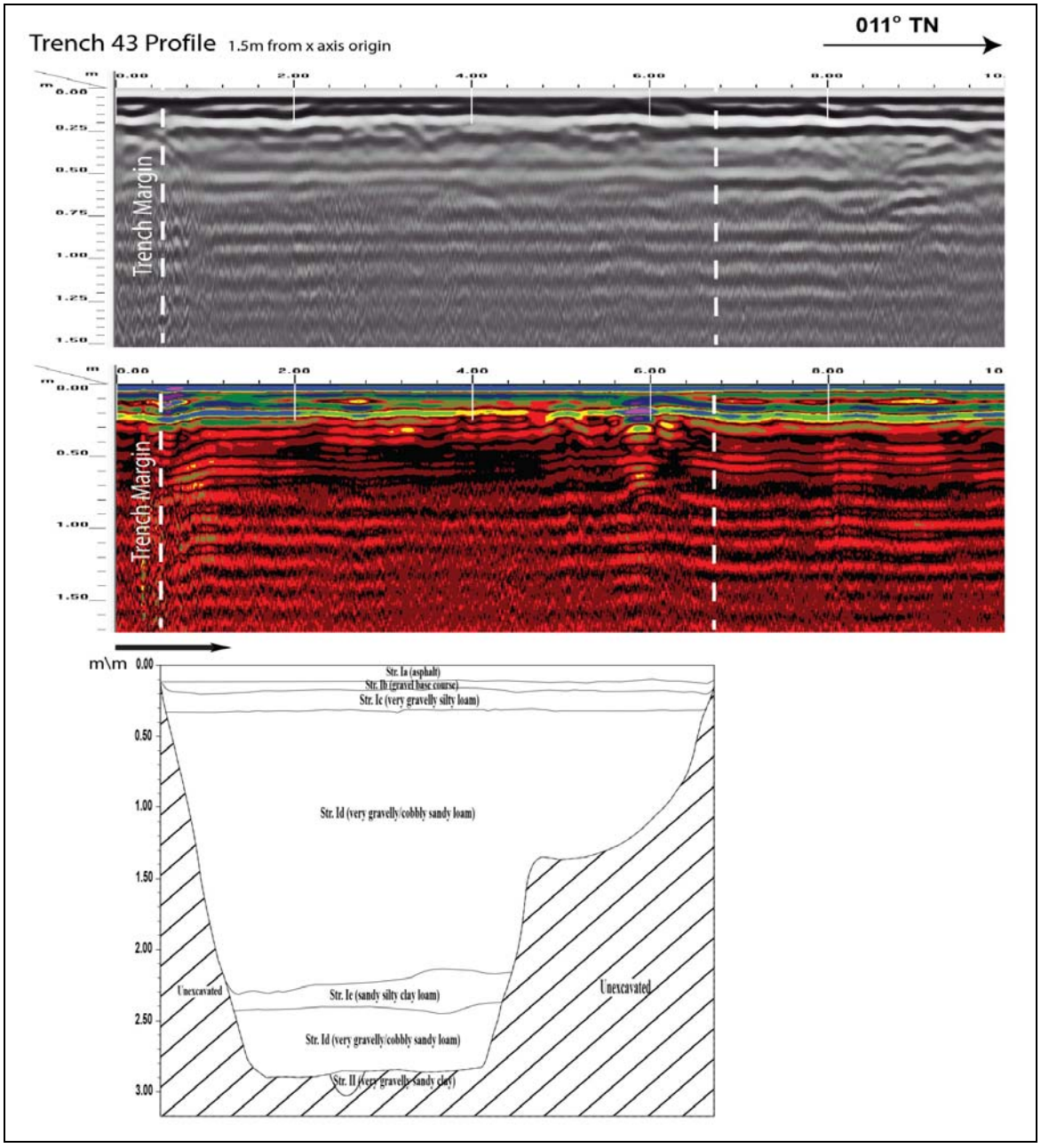

Figure 132. Visual comparison of excavated profile and GPR signal profile of Excavation 43

Excavation 44

Excavation 44 measured 0.6 meters by 6 meters and was oriented East to West and was located within the economy parking lot at the Honolulu International Airport 53 meters South of Ala Onaona Street and approximately 30 meters East of Ala Auana Street. The Lei Stands were 50 meters to the Northwest of the excavation. The GPR grid measured 3 meters by 10 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain lines 15.5 meters to the West and 7 to the East, water line 7 to the East.

A review of amplitude slice maps shows linear features which indicate the presence of utilities within the grid but not within the trench location. Reflectivity is realitively uniform throughout the grid and decreases with depth except for the utilities. A transition from higher reflectivity to lower reflectivity is observed at approximately 50 cmbs with the exception of the utilities (Figure 133).

GPR depth profiles for Excavation 44 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 134). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 75-100 cmbs but no changes in stratigraphy were observed during excavation. Utilities were observed in the profile but not within the excavation boundaries. The maximum depth of clean signal return was approximately 115 cmbs.

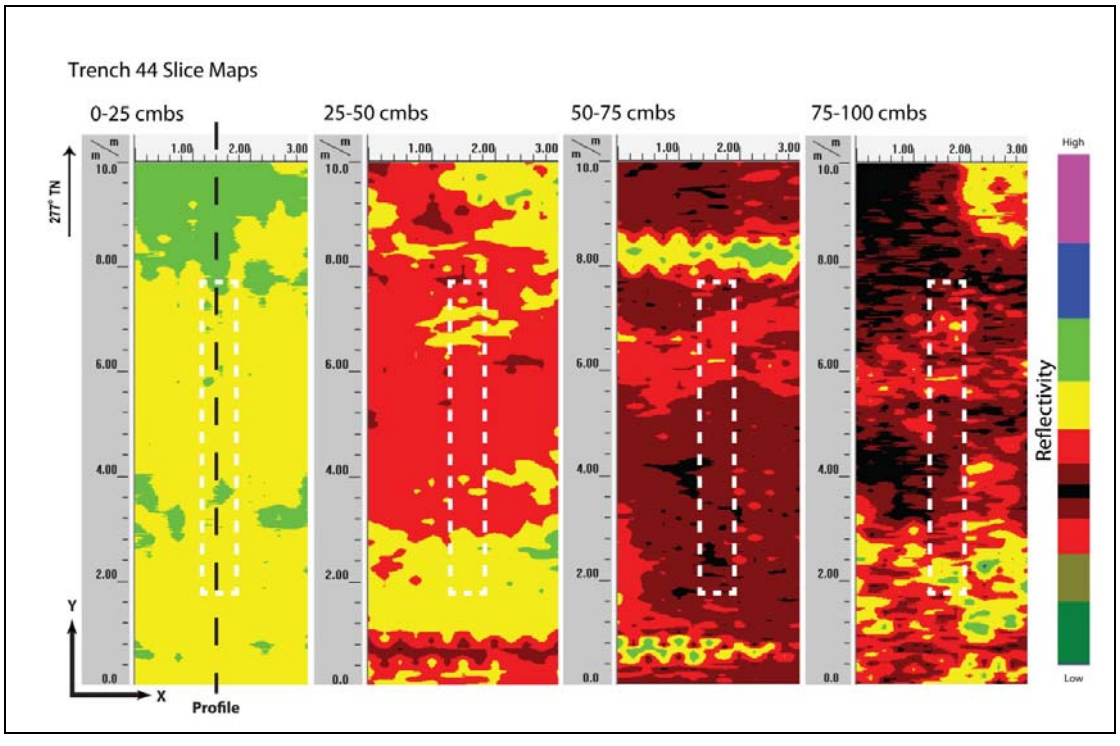

Figure 133. Slice maps of Excavation 44 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 134). Strata Ia through Ic are all clearly observed and occur at the ground-truthed depths. All other sediment transitions are below the maxium depth of clean signal return. There are areas of higher reflectivity around 50-75 cmbs within the excavation location but nothing was observed in this area during excavation. No other discrete objects were observed in the GPR results or subsequent excavation.

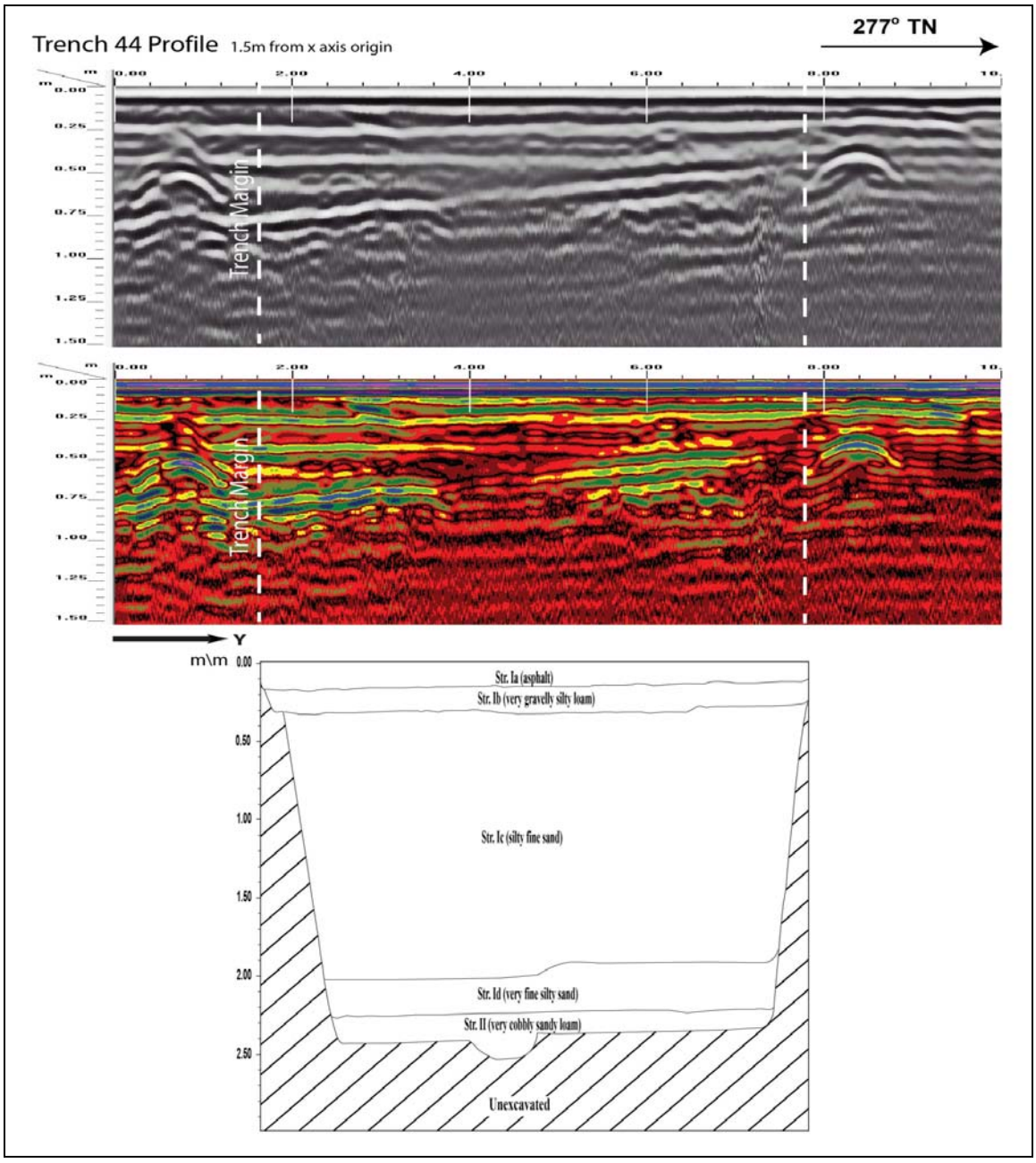

Figure 134. Visual comparison of excavated profile and GPR signal profile of Excavation 44

Excavation 45

Excavation 45 measured .9 meters by 3 meters and was oriented East to West and was located within the economy parking lot at the Honolulu International Airport 63 meters South of Ala Onaona Street and approximately 36 meters East of Ala Auana Street. The Lei Stands were 60 meters to the Northwest of the excavation. The GPR grid measured 3 meters by 9 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: drain line 2 meters to the Northwest. A utility jacket was encountered 60 cmbs in the Northwest corner and 2" PVC fiber optic lines were encountered 44 cmbs running West to South.

A review of amplitude slice maps indicates no linear features although several utilities were encountered. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 135).

GPR depth profiles for Excavation 45 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 136). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. An anomaly was observed in the profile around 45 cmbs which could correspond to the fiber optic utilities found around that same depth. The maximum depth of clean signal return was approximately 100 cmbs.

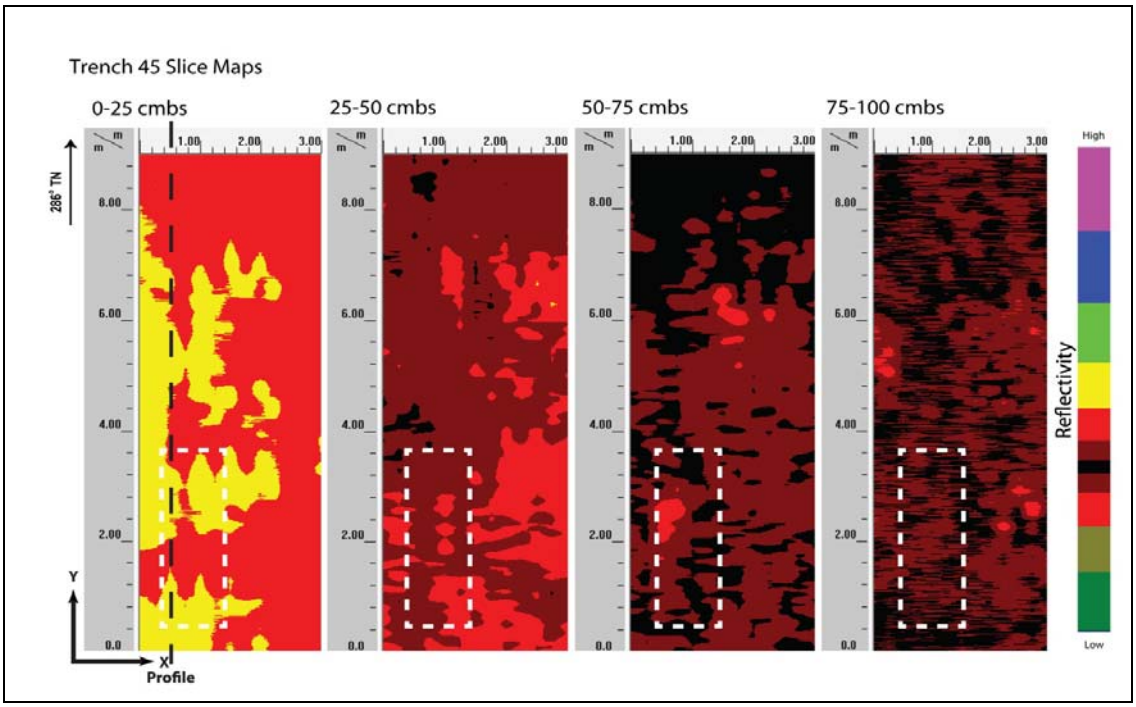

Figure 135. Slice maps of Excavation 45 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 136). The transitions from stratum Ia to Ic is clearly observed and occur at the ground-truthed depths. There is an area of higher reflectivity seen on the grid adjacent to an area that has textural changes and this corresponds to the utility jacket and utilities found within this excavation. No other discrete objects were observed in the GPR results or subsequent excavation.

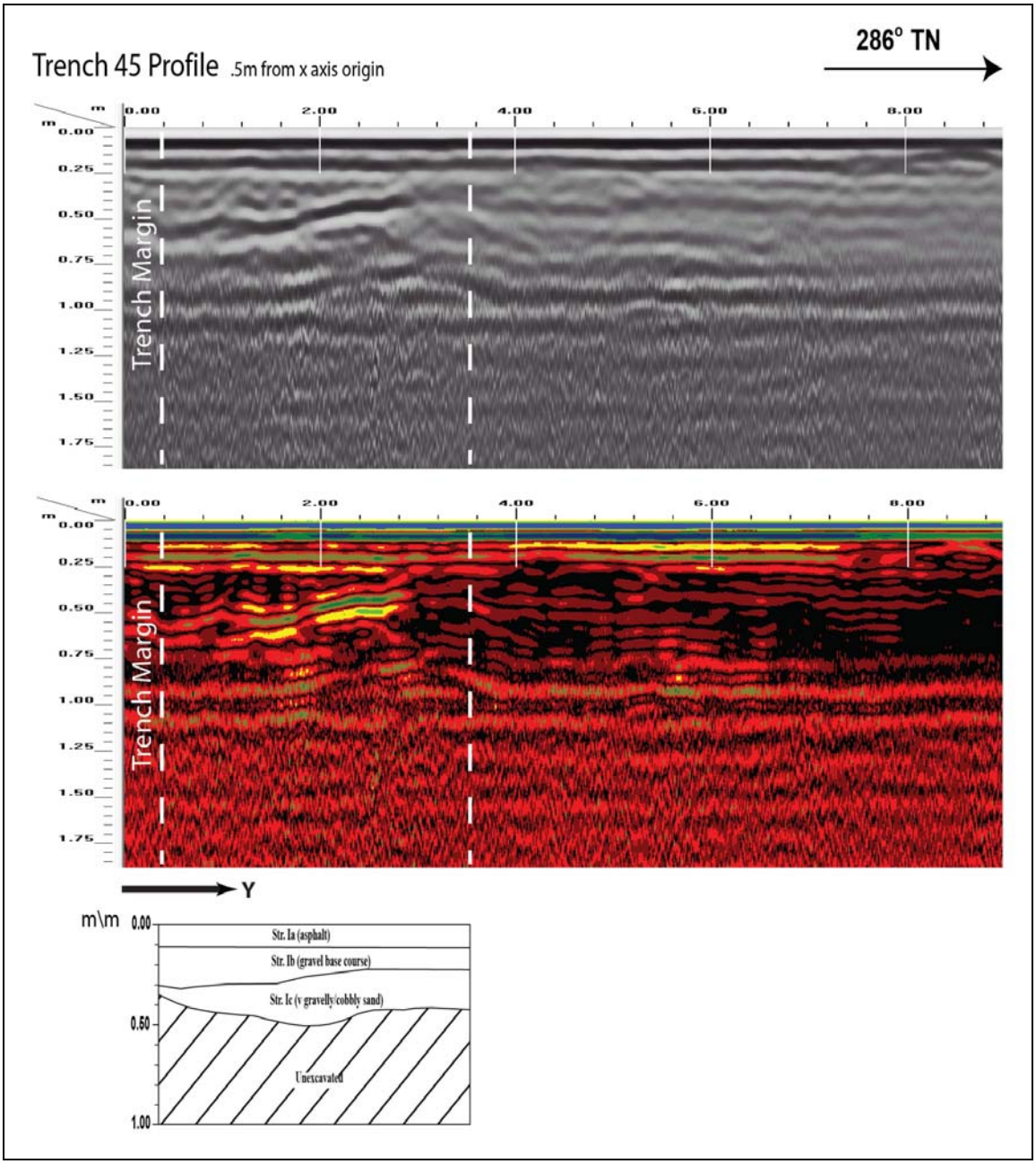

Figure 136. Visual comparison of excavated profile and GPR signal profile of Excavation 45

Excavation 46

Excavation 46 measured 0.9 meters by 3 meters and was oriented East to West and was located within the economy parking lot at the Honolulu International Airport 62 meters South of Ala Onaona Street and approximately 60 meters East of Ala Auana Street. The Lei Stands were 82 meters to the Northwest of the excavation. The GPR grid measured 3 meters by 7 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: water line 1 meter to the North. A PVC pipe was encountered 63 cmbs within the West wall running North to South.

A review of amplitude slice maps does not indicate any linear features although a utility was encountered during excavation. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 25 cmbs (Figure 137).

GPR depth profiles for Excavation 46 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 138). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 25 cmbs. No utilities were observed in the profile although a utility was encountered during excavation. The maximum depth of clean signal return was approximately 85 cmbs.

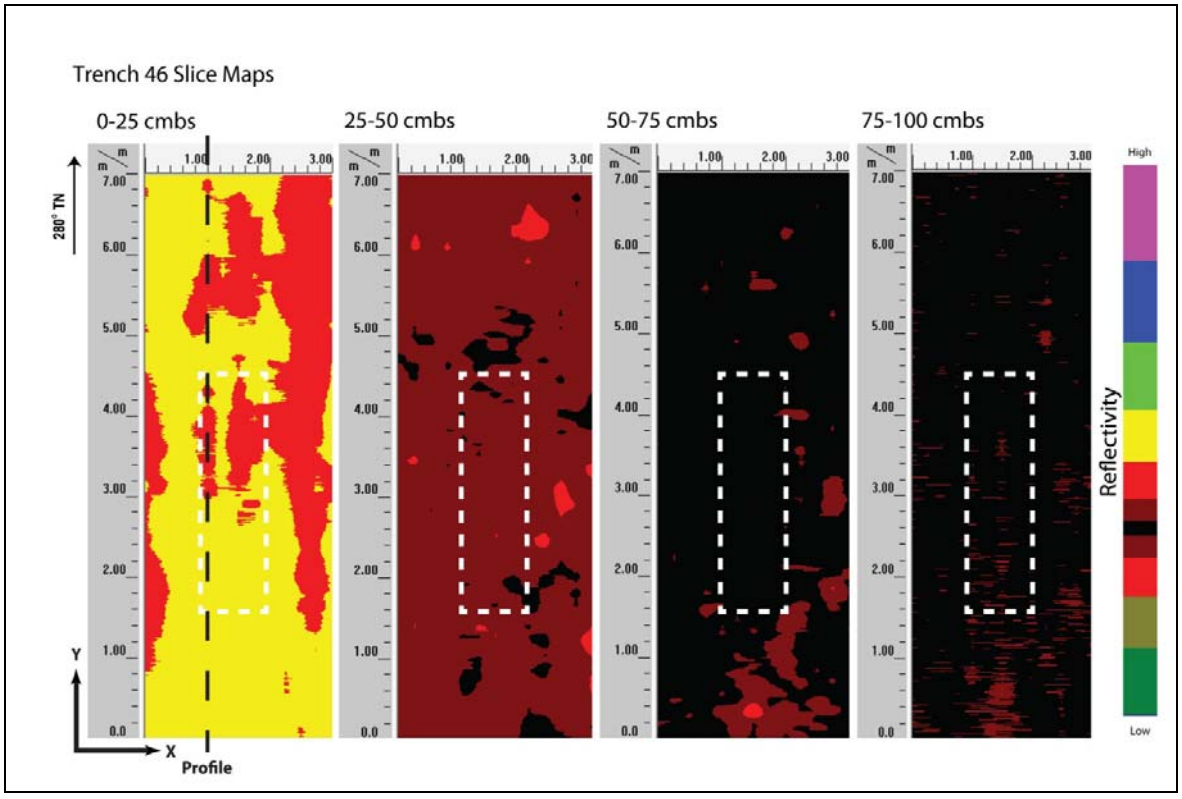

Figure 137. Slice maps of Excavation 46 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a weak correlation in stratigraphic transitions (Figure 139). The transitions from stratum Ia to Ib is clearly observed and occurs near the ground-truthed depths. Due to heavy disturbance, the other transitions were not clearly depicted in the GPR profile at the depths at which they occured. During excavation a utilitity was found within stratum Ic in the Western end of the excavation but was not observed in the profile. No other discrete objects were observed in the GPR results or subsequent excavation.

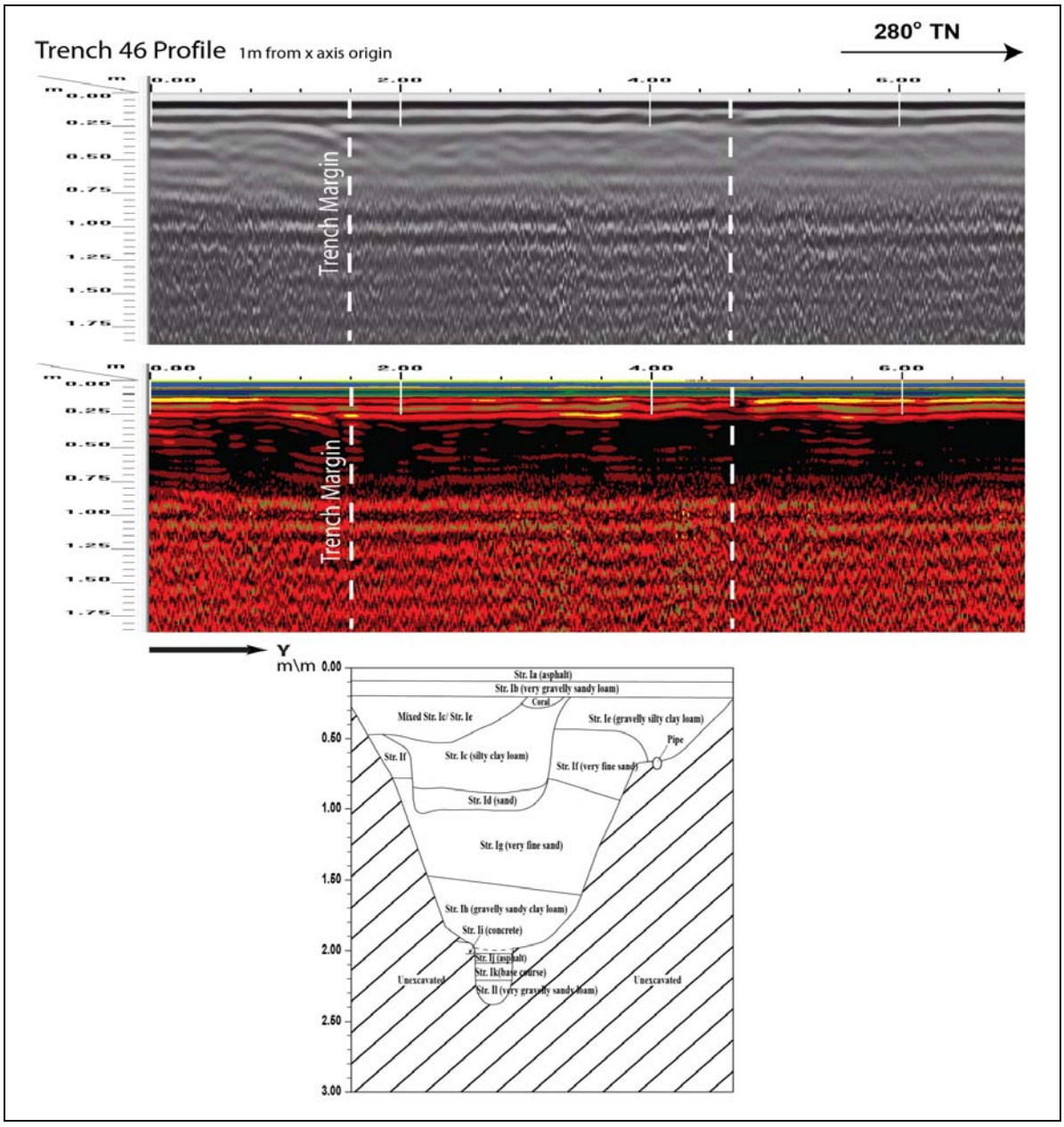

Figure 138. Visual comparison of excavated profile and GPR signal profile of Excavation 46

Excavation 47

Excavation 47 measured 0.9 meters by 3 meters and was oriented North to South and was located within the a parking lot at the Honolulu International Airport 139 meters East of the economy parking lot and 27 meters South of Ala Onaona Street. The GPR grid measured 2 meters by 8 meters with 25 centimeter spacing between Y transects and 1 meter spacing between X transects. Utilities located near the excavation include: power line 10 meters to the Northwest and a communication line 4 meters to the Southeast. No utilities transected the GPR grid or excavation location.

A review of amplitude slice maps indicates no linear features which might indicate the presence of utilities. Reflectivity is realitively uniform throughout the grid and decreases with depth. A transition from higher reflectivity to lower reflectivity is observed at approximately 75cmbs (Figure 139).

GPR depth profiles for Excavation 47 identify horizontal banding, commonly associated with stratigraphic layering, throughout the survey area (Figure 140). This banding corresponds to variations of density and chemical composition within fill deposits. The profile also indicates a change in reflectivity occurring around 15 cmbs and again around 60 cmbs. An anomaly was observed in the profile but was not observed during excavation. The maximum depth of clean signal return was approximately 115 cmbs.

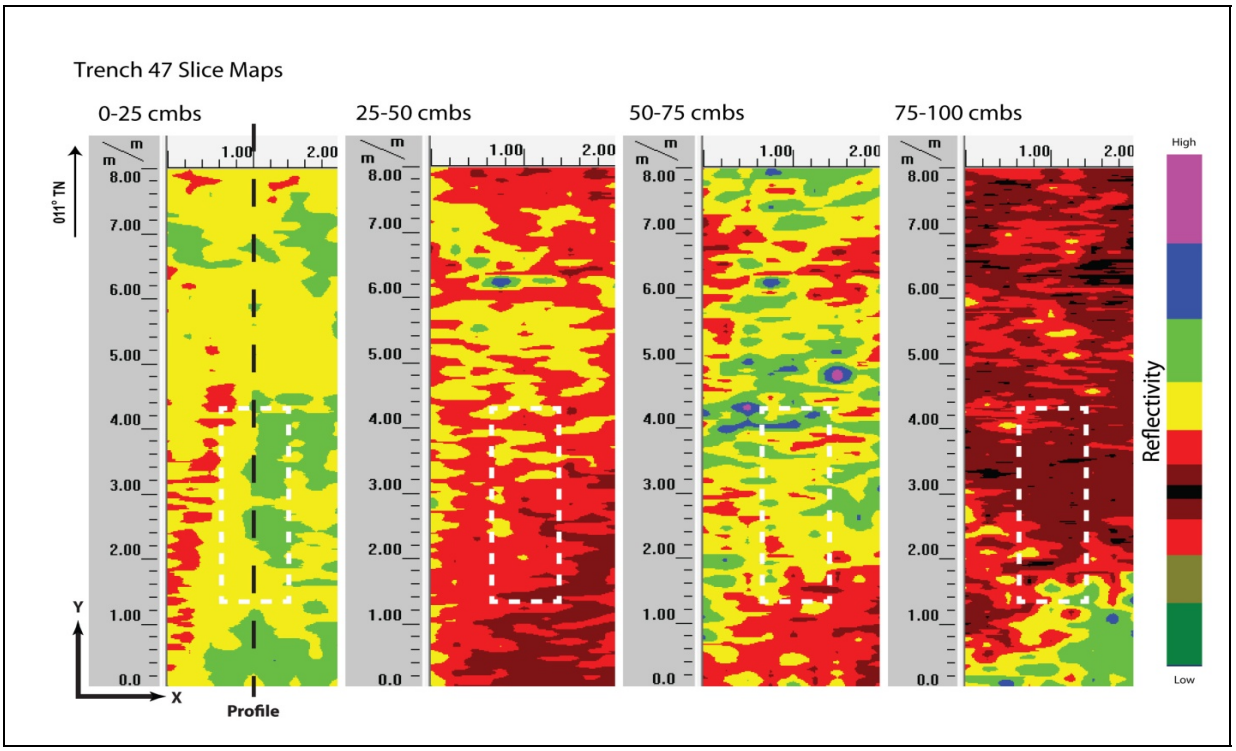

Figure 139. Slice maps of Excavation 47 at 25 cm depth intervals

A visual comparison of the excavated profile and the GPR signal profile shows a strong correlation in stratigraphic transitions (Figure 140). The transitions from stratum Ia to Id is clearly observed and occur near the ground-truthed depths. Textural changes in the form of multiple hyperbolas are apparent in stratum Id which represents very gravelly loam. All other sediment transitions are below the maxium depth of clean signal return. No discrete objects were observed in the GPR results or subsequent excavation.

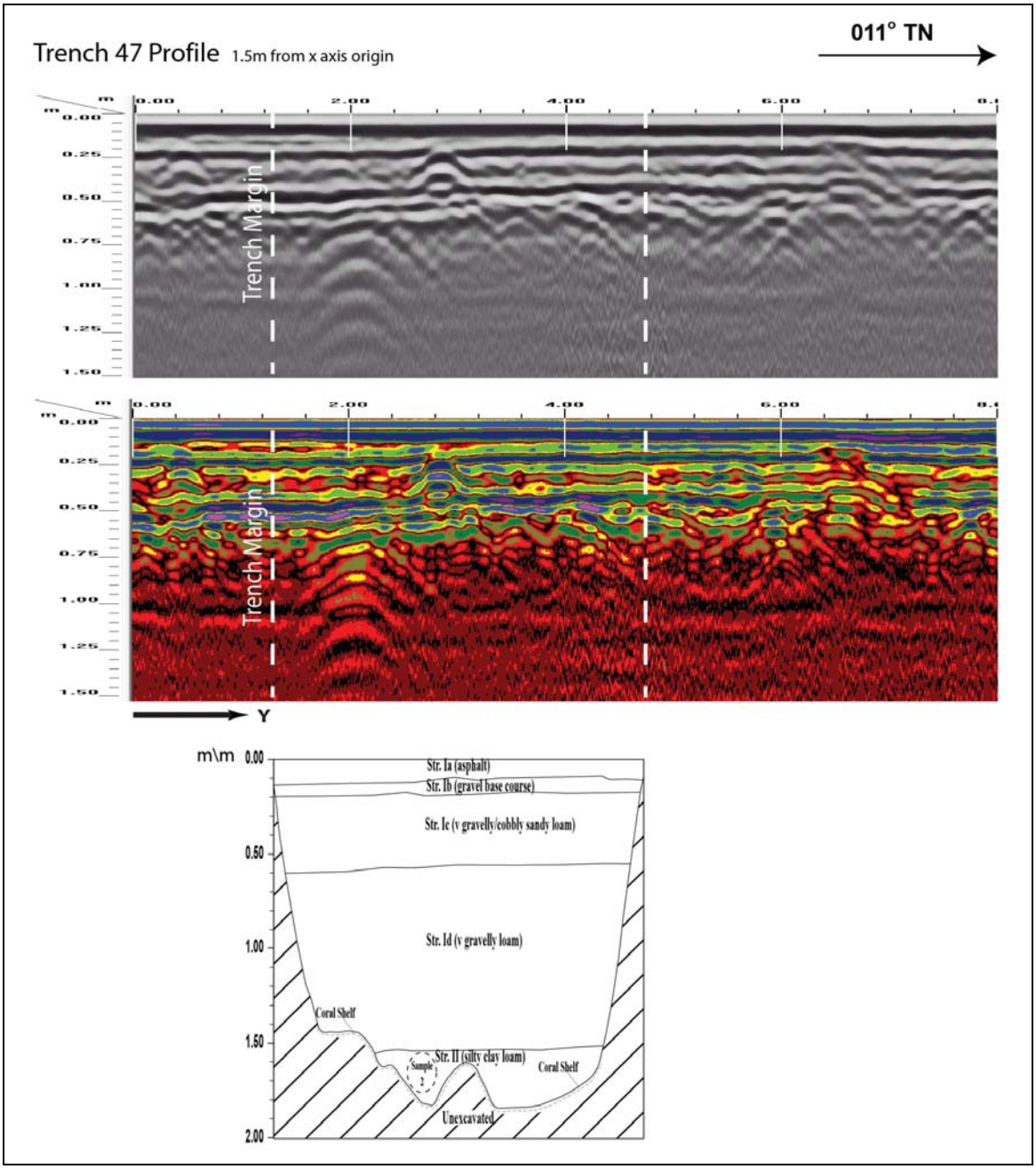

Figure 140. Visual comparison of excavated profile and GPR signal profile of Excavation 47

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